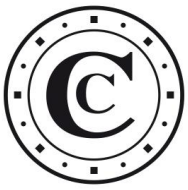
Cour des comptes



THE NATIONAL ARTIFICIAL INTELLIGENCE RESEARCH STRATEGY

A strategy in need of more structure and sustainability

Themed public report

April 2023

Executive Summary

Artificial intelligence (AI) is an old concept, first appearing in the 1950s in the work of British computer scientist Alan Turing. Despite considerable debate in the scientific community over the semantic question of what AI is and where it falls, it can be defined by its purpose – to reproduce human intelligence through the use of computers and mathematics. AI developed mainly from the 1980s onwards, with the emergence of machine learning algorithms. In the 2000s, the growth in computing capacity and access to data encouraged the development of deep learning techniques.

AI has many applications today, and has produced innovation and productivity gains in many sectors. The result has been steady growth in economic investment since the 2010s. According to the OECD, AI start-ups attracted almost 12% of global private equity in the first half of 2018, up from 3% in 2011. Research publications have followed a similar trend, with more than 1.2 million publications in 2019, compared with fewer than 40,000 in 2010. In addition to such opportunities, its growth brings with it a number of challenges, not least ethical, particularly in terms of protecting citizens' rights.

As a result, AI has become an issue of growing priority for public authorities. The adoption of national plans by a number of countries since 2017 to encourage its development bears witness to this, and is a response to the strong competition that exists on an international scale to raise technology levels in countries and attract the best talent. In France, a "national strategy for artificial intelligence" (NSAI) was launched in March 2018, with the aim of positioning France as one of the major AI players on the global stage. Initially endowed with €1,527m of public funding for the period 2018-2022, it has focused on five key components: 1) research, 2) higher education, 3) public transformation, 4) dissemination throughout the economy, 5) defence and security. In November 2021, a new "acceleration" phase for the NSAI was announced for the period 2022-2025, with the aim of strengthening France's competitiveness and attractiveness in this field. This new phase builds on the ambitions of the first phase of the strategy, and the public funding allocated to it is expected to be similar to that for the 2018-2022 period. It has also been drawn up in line with priorities at European level.

Breakdown of the state budget initially earmarked for AI strategy for the period 2018-2022

Key areas of national AI strategy	Estimated state funding (€m)
Research	445
Higher education	128
Transforming public action	154
Economy	390
Defence and security	410
Total	1,527

Source: Court of Accounts processing based on data from the national AI strategy coordinator

This report is an initial NSAI assessment. It covers the "research" and "higher education" components, which are the main funding components, amounting to €1,527m and €1,545m respectively in the first and second phases. Over the period 2018-2022, €445m, or almost 30% of the funding allocated to the strategy, was earmarked for research, compared with €134m, or 8.7%, in the second phase. Meanwhile, funding earmarked for training over the period 2022-2025 has risen sharply (50.2% of allocated funding, compared with 8.4% in the previous phase).

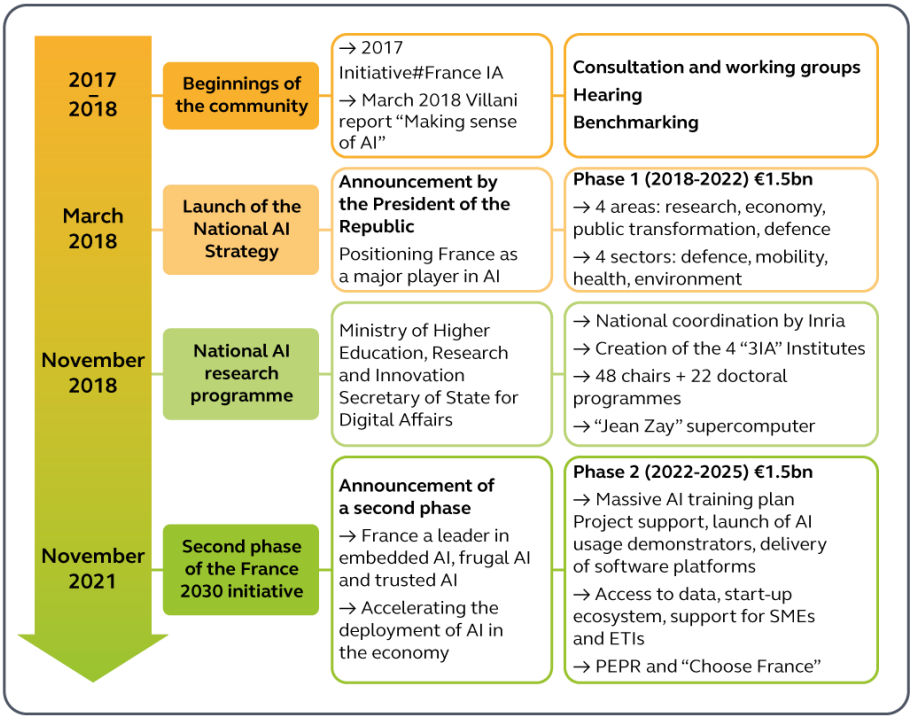
The assessment questions were defined in consultation with the NSAI's stakeholders and the public authorities responsible for its implementation. They were divided into four main questions:

- has the national research strategy strengthened France's position at global and European level? [consistency, effectiveness and efficiency];
- has the national research strategy helped to provide structure for the French AI ecosystem? [relevance and efficiency];
- is the national research strategy for centres of excellence effective and efficient? [effectiveness and efficiency];
- has the national research strategy improved the consideration of ethical issues (frugal and trust-based AI)? [relevance, consistency and effectiveness].

In response, an unprecedented effort to semantically analyse and exploit numerous databases based on statistical and econometric methods was carried out in order to quantify and assess the results of the strategy. This quantitative component was supplemented by numerous semi-structured interviews and focus groups, in addition to a consultation with AI researchers and a participatory workshop with experts in the field.

In 2018, France was one of the first countries worldwide to have a formalised plan for AI. Since then, many countries have drawn up national strategies or specific measures.

Stages in the development of the national AI strategy



Source: Court of Accounts

Initially, the French strategy gave priority to AI research. In addition to the 30% of funding allocated to it for the 2018-2022 period, research has also been the subject of a specific plan, entitled the "national artificial intelligence research strategy" (NAIRS), coordinated by the French national institute for research in computer science and control (Inria). International comparisons based on OECD data, and the more specific study carried out by the Court of Auditors on the AI strategies or public policies of 10 countries [1], show that identifying research as a strategic priority is the most frequent choice made by governments.

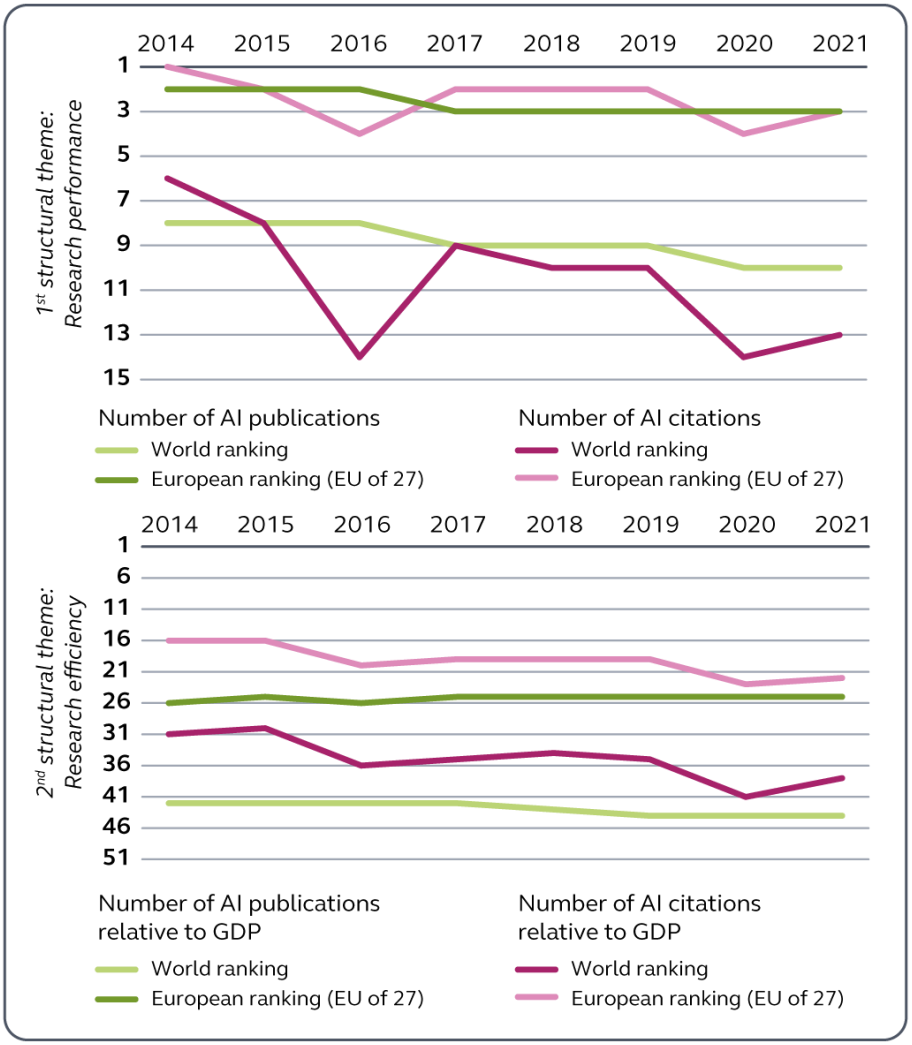
Since its launch, most of the measures planned in the NAIRS have been implemented. In establishing a formal strategy, the public authorities have given a strong political signal about the importance of AI for French research. In fact, over and above the actions set out in the strategy, this is now a key issue in all discussions within a number of research organisations. Evaluations and – more importantly – econometric analyses of global data support the decision to adopt a strategic plan. However, the effectiveness of the strategy to strengthen France's position in AI, in line with the objective initially set for it, has not been proven. Over the period analysed, in terms of the number of AI publications and out of a total of 47 countries compared, France has barely maintained its position in 10th place worldwide, and remains in 2nd place in Europe. However, given the long timeframe involved in research, it is not yet possible to reliably assess the real-world effects of the strategy on scientific output.

In addition, the funding put in place needs to be monitored more closely in order to measure the effects of the financial efforts of this AI strategy on France's scientific standing and organisational structure. The resources allocated to the strategy do not cover all public investment in AI. For the research component, €554.6m was ultimately committed over the 2018-2022 period, although the actual implementation of appropriations is not tracked in a comprehensive and summarised way.

With a view to attracting talent, certain financing tools would benefit from being made permanent. The vast majority (over 80%) of funding was distributed via short-term financial instruments, using calls for projects. However, the lack of clarity over the long-term future of these funding windows is likely to create disruptive effects in training for young researchers (doctoral programmes) or the continuation of research programmes (academic chairs).

[1] United States, Canada, Germany, Finland, Italy, Netherlands, United Kingdom, Switzerland, Israel, Japan.

France's ranking in the world and in the EU of 27 according to complementary and differentiating criteria on the international scene

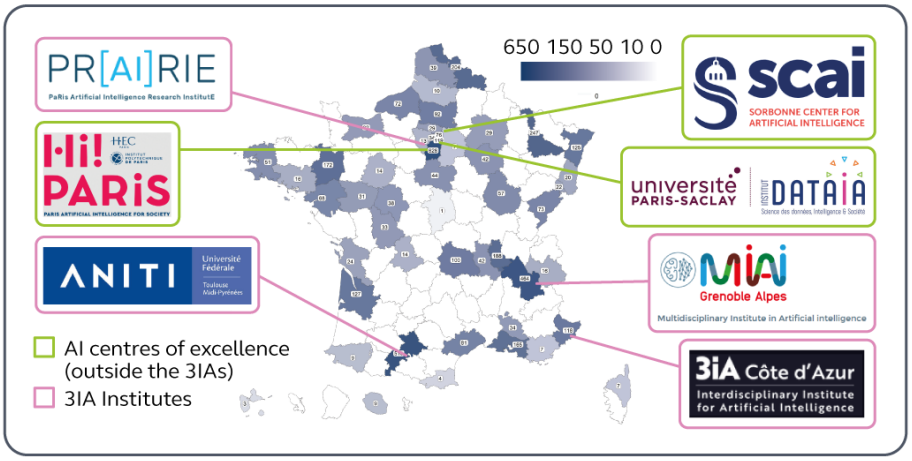


Source: Court of Accounts
Reading note: With regard to indicators relating to the efficiency of research, it should be noted that the Covid-19 crisis may have had an impact on countries' GDPs from 2020 onwards. Tracking country rankings helps to limit the biases associated with standardisation by annual GDP, as shown by the relative stability of the two applicable time series over the period from 2019 to 2021.

The main thrust of the strategy is the creation of centres of excellence in AI [2], through the accreditation of interdisciplinary AI institutes (3IA), the establishment of individual chairs, and the identification of centres of excellence outside the 3IA institutes. The result is a strengthening of geographical areas already active in artificial intelligence, the structuring of an ecosystem and an increase in the scientific output of the sites, although it is not possible to demonstrate the impact of the strategy on the latter development.

[2] The "centres of excellence" bring together three types of entities: the four interdisciplinary AI institutes (3IA institutes) identified during the first phase via a specific ANR call for proposals; the 43 individual chairs held by a researcher identified via another specific ANR call for proposals; the three other centres of excellence, known as "non-3IA", identified by the strategy coordinator in 2021, without being the subject of a call for proposals and whose members may hold an individual chair.

Establishment of themed AI institutes (3IA PR[AI]RIE, MIAI, 3IA Côte d'Azur and ANITI) and centres of excellence (SCAI, DATAIA and Hi! PARIS) compared with areas historically active in this field



Source: Court of Accounts
Reading note: Historical activity in AI is measured through the departmental distribution of AI theses defended between 1989 and 2019 in French higher education establishments, based on open data from theses.fr (ABES). Theses are listed by the year in which they were defended. AI theses are identified using the semantic method developed by the Court. The logos of the 3IAs and AI centres of excellence are taken from their official websites.

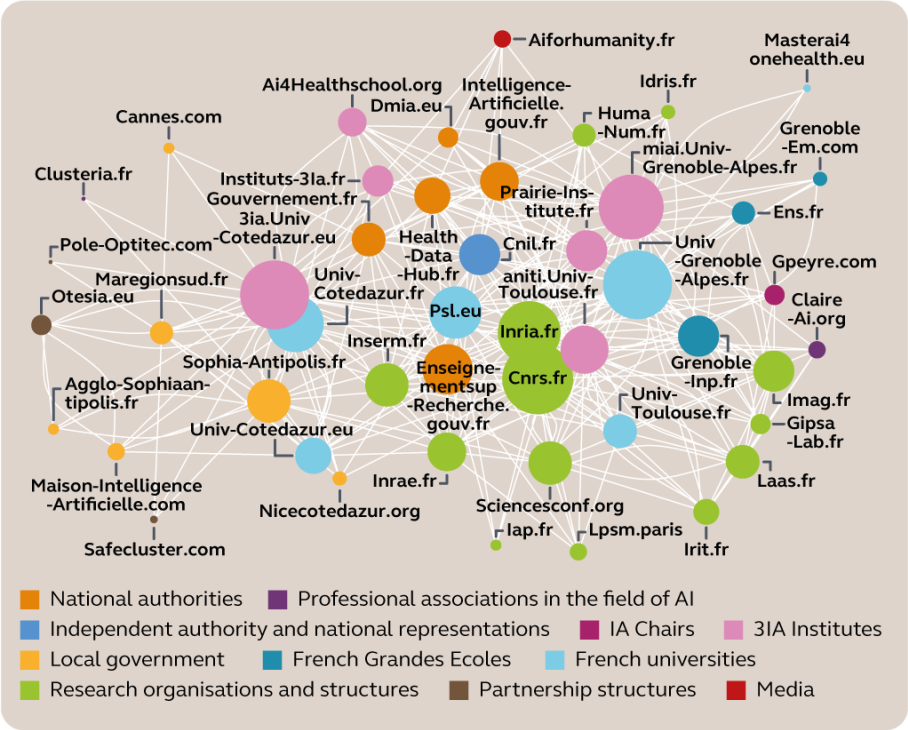
Synergies between centres of excellence need to be strengthened; for example, by adopting a more systematic approach to promoting each other's work. This would help to raise their profile both nationally and internationally, as well as enhancing France's image as a magnet for foreign talent.

At the same time, the work of the 3IA and non-3IA centres of excellence needs to be clarified. The non-3IA centres of excellence were identified after the 3IA institutes had been labelled and – unlike the 3IA institutes – without any competitive call for projects involving an independent jury. The public authorities' expectations of them are therefore less explicit, and their development model less constrained by funding conditions. They are, however, involved in the second phase of the strategy just as the 3IA institutes are. This review process must be accompanied by a review of the timeframe for funding allocated to accredited institutes (currently four years), which is too short-term to allow for leverage effects.

The lack of clarity over time in the associated funding has also been identified for the training of young talent through doctoral programmes and Convention Industrielle de Formation par la Recherche (CIFRE) contracts. Although the strategy has sent out a strong signal in favour of such an approach, it is now important to ensure that the funding needed to sustain this momentum is sustained.

The evaluation shows that the NAIRS provided a means of structuring AI research stakeholders, at a time when AI was not identified as a discipline in its own right. However, this structuring still needs to mature: a comparison of French and German stakeholders based on a network analysis shows that in France, this structuring is still mainly organised around the main research bodies, whereas German university sites and multidisciplinary centres are more effective in structuring their national ecosystem.

Representation of the French sub-network resulting from the 3IA institutes



Source: Court of Accounts, based on the web and the Hyphe tool from Sciences Po Paris

In order to improve coordination between the various players, it is urgently necessary to make changes to the strategy's governance and management. The performance model that was initially developed was ultimately not used. There is no annual report for monitoring the progress of the strategy. Its steering mechanism, provided by national coordination, is not in a position to monitor the various stages of the project, to check funding and expenditure, or to rectify any difficulties that may arise. It has weakened over time, and runs the risk of becoming inoperative. No specific governance arrangements have been put in place for the research component, with Inria being the only operator represented on the strategy's overall steering committee. Making changes to governance could provide an opportunity to create a shared overview of public action in AI, at a time when the measures decided upon in this area remain dispersed across several public policies.

Although the national research strategy has not yet strengthened France's position at global level, the first component of the strategy has prevented the country from falling behind in science terms since 2018. The second component is now crucial to improving France's position in AI in terms of global competition. This "AI acceleration strategy" is refocused on the objective of training AI talent, a priority that has received little attention to date. Total funding for this priority amounts to €776m, including €500m for the "excellence" component and €276m for the "massification" component. The launch of the "Skills and Trades of the Future" call for expressions of interest (AMI CMA) in 2022 is one of the ways in which this effort is being seen operationally.

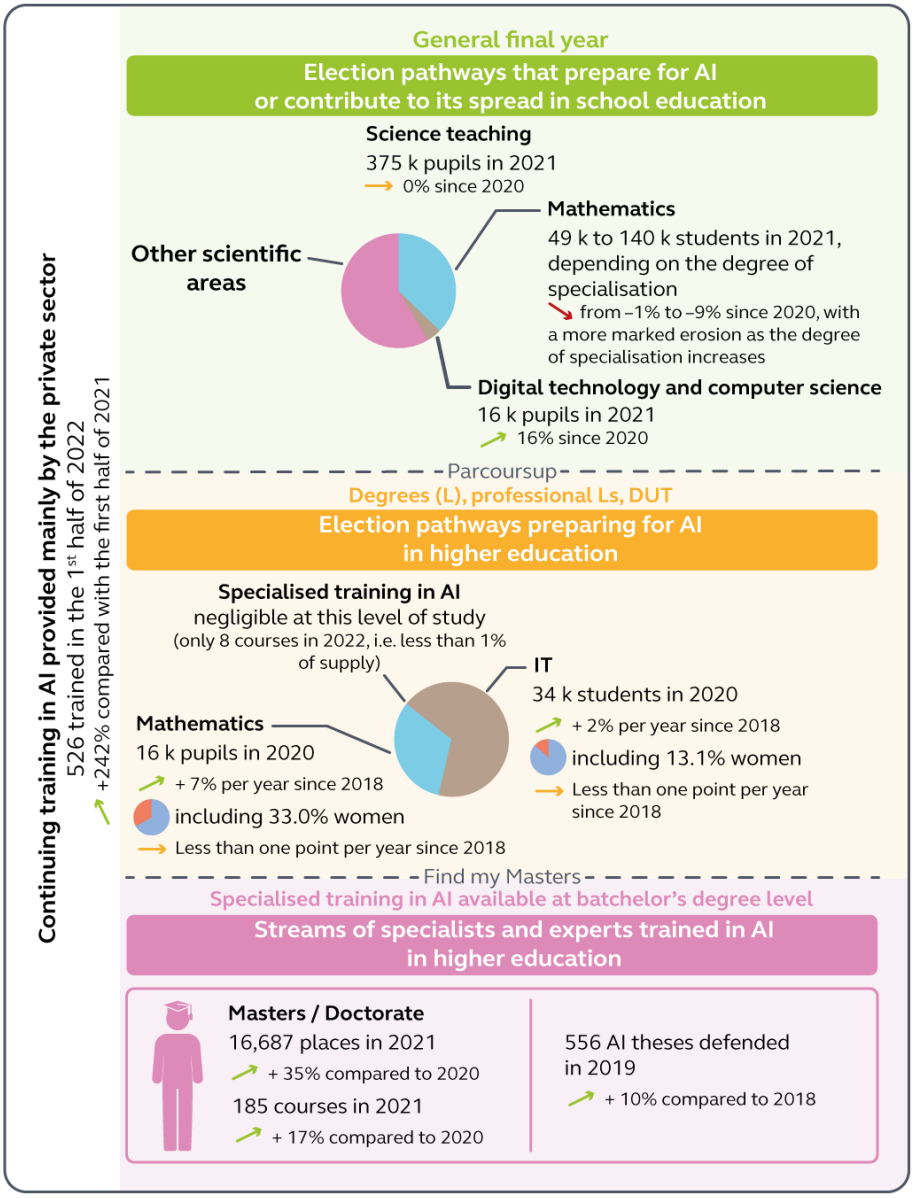
Funding for the second component of the NSAI – acceleration strategy (in €m)

In €m	Research programme	Decentralised and embedded AI	Trusted AI	Dissemination of AI & responsible AI demonstrators	Skills and talents	Total
Public funding	134	265	111	259	776	1,545
PIA 4	73	263.5	97.5	123		557
France 2030					700	700
Other State and local authority loans	61	1.5	13.50	136	76	288
Private financing		310	105	86	5	506
European Union		60	10	16		86
Total	134	635	226	361	781	2,137

Source: Restated by the Court of Accounts based on the press kit of 8 November 2021 and data from the national coordinator

The current limited number of high-calibre public trainers could impede our stated ambitions, especially as there is a tension between investment in teaching and excellence in research. The number of specialist trainers in public higher education is currently insufficient to meet AI training needs, both for initial and continuing training.

Mapping of training courses and growth in the number of learners trained in AI and in its "upstream" election sectors



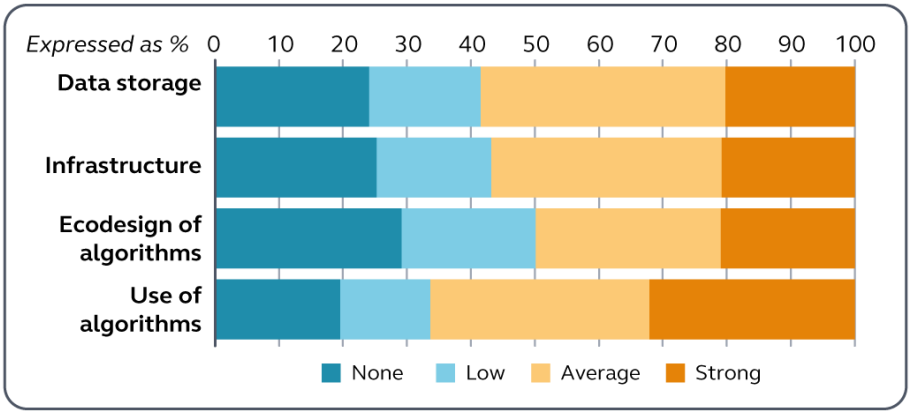
Source: Court of Accounts based on data from the MENJS, the MESR and the Caisse des Dépôts et Consignations, with semantic filtering applied to identify training courses specific to AI. The term "k" represents thousands

For the previous graph, the order of magnitude of the total number of academic AI experts is estimated on the basis of information provided by research operators and universities as part of the consultation carried out by the Court, as well as on the basis of the number of teaching and research staff in university departments where AI is prevalent.

The French approach would benefit from being even more closely integrated into the European approach. Various European research support programmes are designed to encourage the development of AI, including "Horizon Europe" (a total of almost €100 billion over the period 2021-2027) and "Digital Europe" (a total of €7.5 billion over the same period). The priorities of the French strategy were developed in 2018, taking into account the European plan for AI initiated in 2018 and updated in 2021. The acceleration phase now offers the opportunity to further capitalise on the efforts made at European level.

Trust [3] and frugal use of resources [4] are two of the four key themes of the €73m Priority Research and Equipment Programme (PEPR), which is part of the acceleration strategy. However, there is still a need to improve the scientific community's understanding of these issues. Consultations with AI researchers by the Court show that these issues are currently given little consideration in research work.

Perception of how environmental impact is taken into account in research



Source: Court of Accounts – Consultation of the scientific community with respect to AI

This issue is particularly acute with regard to the concept of "frugal AI", with a potential tension between resource efficiency and performance. Frugality should be better integrated into calls for projects; for example, by drawing up a charter or guide to good practice.

For the research component, priorities in this second phase are refocused on attracting talent and addressing social issues, such as trust in AI and frugal use of AI resources. This latest development reflects a reorientation of the research component, which has a greater focus on applied research to take account of the growth of industrial AI.

[3] Trusted artificial intelligence is characterised by its interpretability, explicability, transparency and "responsible" identity.
[4] Frugal artificial intelligence is sustainable and respectful of the environment in its efforts to minimise its consumption of energy and resources.

Audit recommendations

1. Translate public policy on artificial intelligence into a summary budget document that will enable it to be monitored and its effects measured (*MEFSIN*).
2. Specify the respective roles of the 3IA and non-3IA centres of excellence, and then clarify the multi-year funding allocated to them (*MESR, SGPI*).
3. Establish shared objectives and priority indicators for public policy on AI, in line with European strategy (*MEFSIN, SGPI*).
4. Create a scientific and steering committee at Inria, co-chaired by France Universités, to monitor the implementation of the strategy and define future strategic orientations (*MESR, Inria*).
5. Draw up a harmonised, up-to-date map of AI training courses to be promoted via a shared certification label in order to raise their profile and support their expansion (*MESR*).
6. Forecast the need for secondary school teachers, teacher-researchers and researchers trained in the use of AI, and draw up appropriate training plans (*MESR*).
7. Draw up a charter and a catalogue of best practices to define and monitor the environmental impact of AI research, and encourage the development of responsible AI (*SGPI, MESR*).