

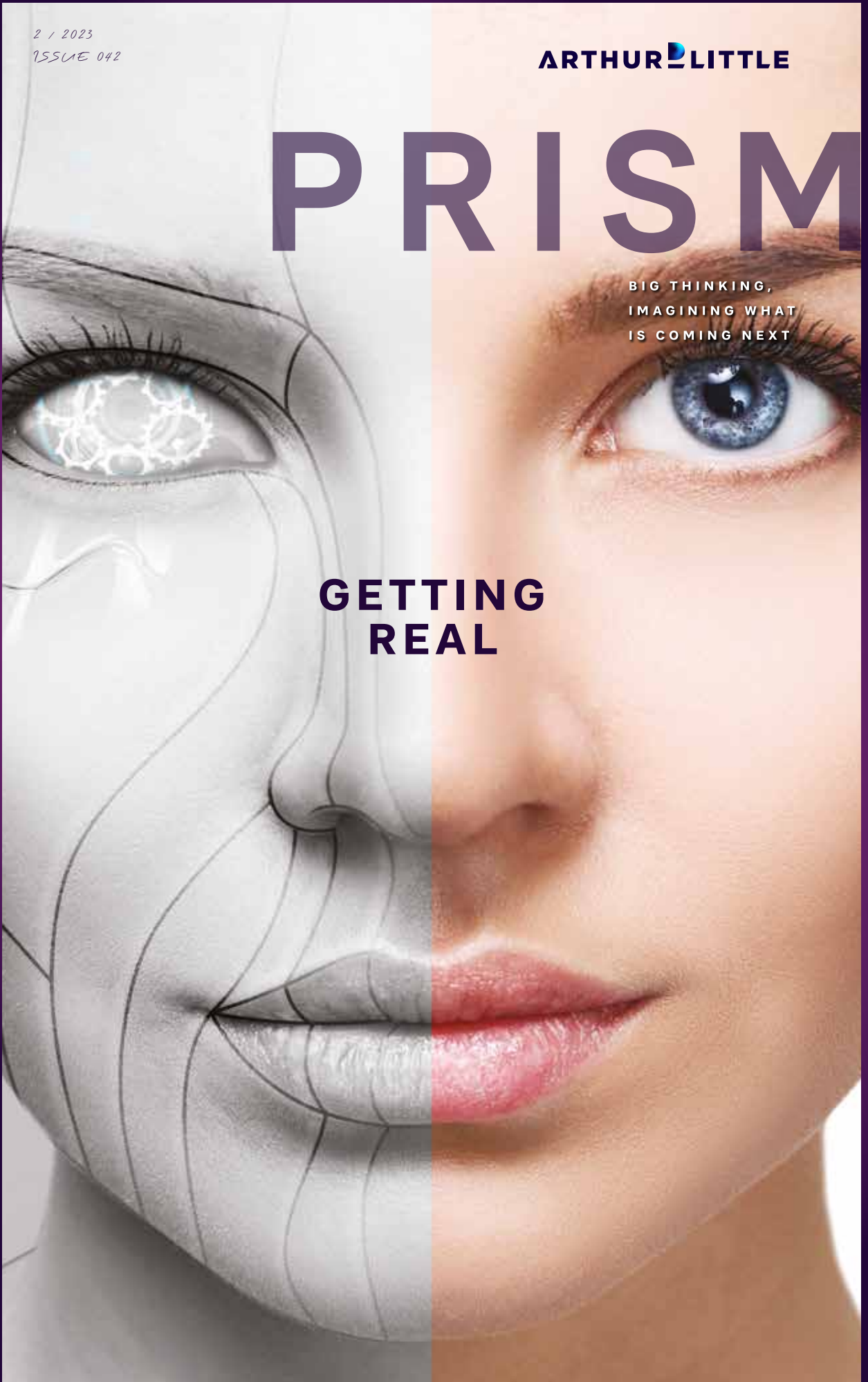
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ARTHUR LITTLE

# PRISM

BIG THINKING,  
IMAGINING WHAT  
IS COMING NEXT

GETTING  
REAL



## THE PRISM BOARD

**Shinichi Akayama**

akayama.shinichi@adlitttle.com

**Etienne Brumauld des Houlières**

brumaulddeshoulières.etienne@adlitttle.com

**Rick Eagar**

eagar.richard@adlitttle.com

**Dr. Raymond Khoury**

khoury.raymond@adlitttle.com

**Dr. Michael Kolk**

kolk.michael@adlitttle.com

**Barnik Maitra**

maitra.barnik@adlitttle.com

**Michael Majster**

majster.michael@adlitttle.com

**Francesco Marsella**

marsella.francesco@adlitttle.com

**Albert Meige**

meige.albert@adlitttle.com

**Daniel Monzon**

monzon.daniel@adlitttle.com

**Andreas Schlosser**

schlosser.andreas@adlitttle.com

**Ben van der Schaaf**

vanderschaaf.ben@adlitttle.com

# ARTHUR LITTLE

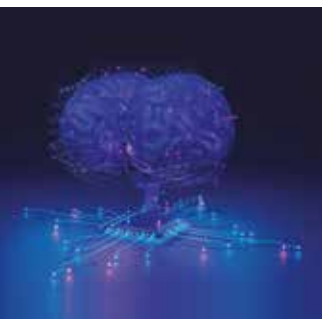
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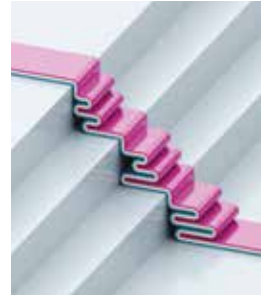
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# EDITORIAL

## DEAR READER

“Get real!” is what you say to someone when they get so carried away with an idea that they forget the practicalities.

You might think that the business world, with its hard-nosed executives, practical managers, and demanding shareholders, is already as real as it gets. However, in many ways it’s just as susceptible to hype as any other group. Take the Metaverse, for example – it may well be transformational eventually, but right now, there’s the very practical issue that most people don’t want to spend large amounts of time isolated from the real world. Artificial Intelligence (AI), too, while it has massive potential, has some practical issues around data security, privacy, and accuracy that should not be underestimated.

Which brings us to our lead article for this Second Semester 2023 edition of Prism. For businesses, one of the most obvious applications of AI is knowledge management. But relying on third-party open-access tools such as ChatGPT has some big drawbacks for a company handling confidential and sensitive data. Based on some in-house pilots, we demonstrate the potential and value of in-house customized AI bots. Could this be the real future of AI for business?

And on the Metaverse, too, while the initial hype wave has well and truly passed, we strongly suggest businesses don’t write it off just yet. In our second piece, we look at how the Industrial Metaverse, through developing further from existing digital twin technology, can offer practical benefits to companies without the need for fully virtual environments.

Digital twins, however, are not much use without connectivity to the real world. Connectivity is an essential aspect of any digitalization strategy, but is often treated by companies as mainly a tactical or technical issue. But as scale and complexity increase, this approach is becoming increasingly inadequate. Our third article explores how to take a more strategic approach to the connectivity challenge.

Next, we turn to the energy transition and the huge challenges of achieving stable baseload power from renewable energy sources. Although many countries dismissed nuclear power following Chernobyl and Fukushima, today there’s growing interest around the world in small modular nuclear reactors (SMRs) as a potential contributor to the future energy mix. If we are really going to “get real” about achieving full energy transition, could SMRs be part of the solution? We explore the pros and cons.

Digital infrastructure is as fundamental in the 21st century as railways, roads, and bridges were in the 19th and 20th centuries, and our next two articles focus on this. First, we share some fascinating results from recent work comparing how well national governments around the world have performed in digitalizing their economies. And second, we zero in on the challenge of providing public digital platforms and solutions that are accessible to all for basic services such as payments, health, and identity. Recently, India has achieved impressive results with its Digital Public Goods platform, empowering countries and reducing dependence on the global tech giants. We explain how it was done and what it means for both government and business.

A recent phenomenon fueled by digitalization is the rise of digital-first “challenger brands,” start-ups that are threatening big established consumer brands by building significant scale in a matter of months rather than decades. In our next article, we look at how they do this and what lessons can be learned for others.

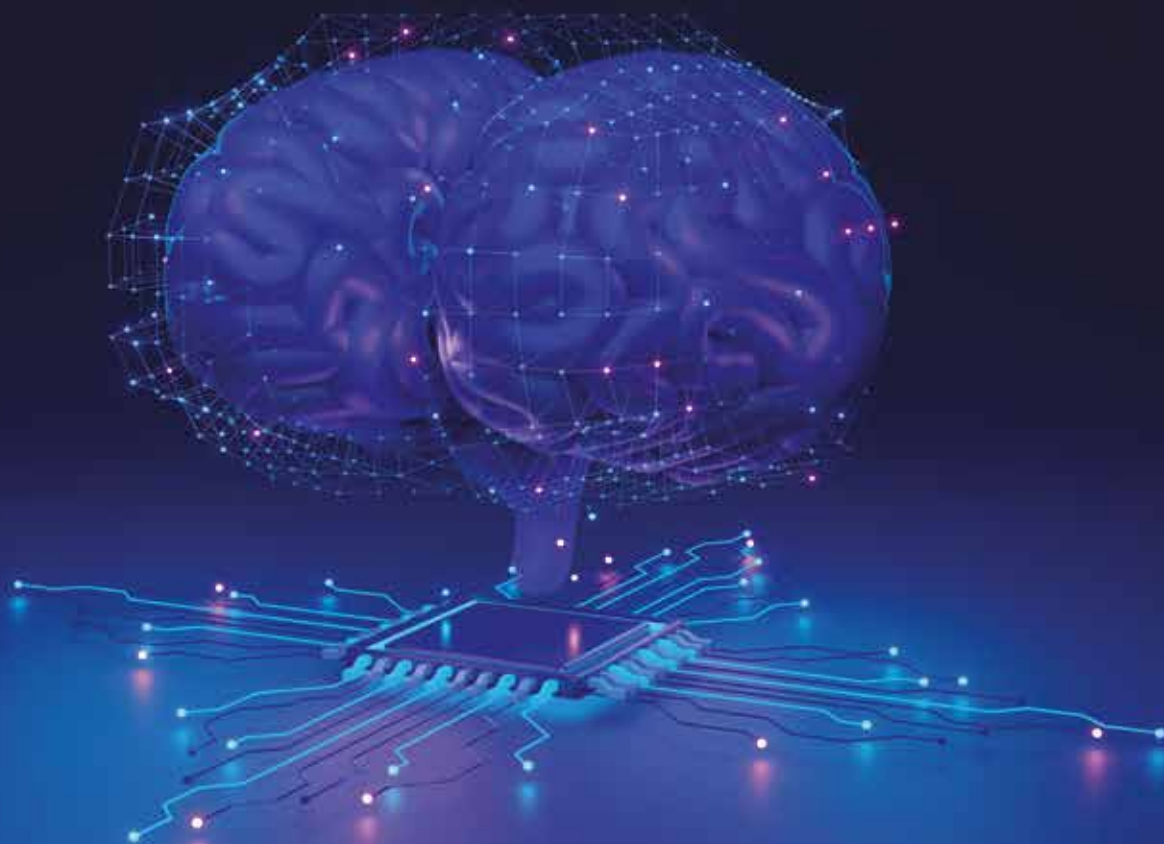
And finally, we bring you an updated perspective on the growing momentum behind hydrogen as countries continue to struggle with the energy transition. There are great opportunities, but still many challenges – what does it mean for end users and players in the energy value chain? To provide his unique perspective on this, we are delighted to bring you an exclusive interview with Pascal De Buck, the Chief Executive Officer of Fluxys, one of the leading energy infrastructure companies in Europe, which is focusing strongly on facilitating and accelerating the energy transition through hydrogen as well as renewables.

We hope you enjoy this semester’s packed issue, and as always, we look forward to hearing your feedback!



**Rick Eagar**  
Chief Editor, Prism  
Arthur D. Little

# TAKING CONTROL OF AI



**CUSTOMIZING  
YOUR OWN  
KNOWLEDGE BOTS**



## AUTHORS

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Nicholas Johnson, Michael Papadopoulos, Foivos Christoulakis,  
Gregory Brown, Anastasiya Tikhonova, Eystein Thanisch

**For decades, organizations have struggled to connect employees with the internal knowledge and insights they need to make better, more informed, and timelier decisions. Finding the right information, at the right time, among the increasing volumes of structured and unstructured corporate data, and delivering it in the right format is business-critical. However, it is often like looking for a needle in a haystack.**

AI can finally overcome this challenge. Essentially, the ability of Large Language Models (LLMs) such as ChatGPT to create bespoke content is game-changing when combined with Natural Language Processing's (NLP's) capacity to find, process, and format information. However, using completely open LLMs as the engine for a critical business process such as enterprise knowledge management may give executives pause for thought.

Based on first-hand research and practical pilots, this article sets out how companies can harness the huge benefits of AI to manage knowledge across the enterprise, without having to take the risks inherent in relying entirely on an open-access LLM.

## THE DRAWBACKS OF LARGE LANGUAGE MODELS

The explosion in the use of ChatGPT and other LLMs promises to transform business and society. Better sharing of knowledge and information is a key use case for business, with clear benefits for companies and employees. However, simply introducing a third-party tool such as ChatGPT into an organization to underpin intelligent knowledge sharing through AI bots has multiple drawbacks:

- It exposes your corporate data to the provider of your LLM (OpenAI in the case of ChatGPT). While this is acceptable for generic data, it risks leaking proprietary knowledge to the world. In a recent example, Samsung banned staff from using LLMs after sensitive data was uploaded to the ChatGPT platform.

- Due to their size, bigger LLMs have a training cut-off period, and don't "know" about anything that has happened since then. ChatGPT, for example, is only aware of data up to September 2021.
- LLMs have been shown to suffer from "hallucinations," confidently providing answers that are fundamentally inaccurate. And, given that they are trained on the internet, the information they provide may be based on untrue data, a risk that could increase over time as AI bots generate increasing amounts of that data themselves.
- In a fast-emerging market, regulators are struggling to catch up with technology. This introduces the risk that if you embed a third-party LLM into your organization, regulators may subsequently decide to impose conditions on its use. For example, the Italian government temporarily banned ChatGPT in April 2023, citing privacy concerns. Many countries are moving towards regulating AI in some format.

## TAKING CONTROL OF AI

Rather than being reliant on third-party tools, organizations can instead implement their own LLM. This should be built on one of the numerous commercially exploitable base models and focused and trained on the organization's own internal data. This provides a significant advantage in terms of privacy and security since data is retained within the organization's infrastructure.

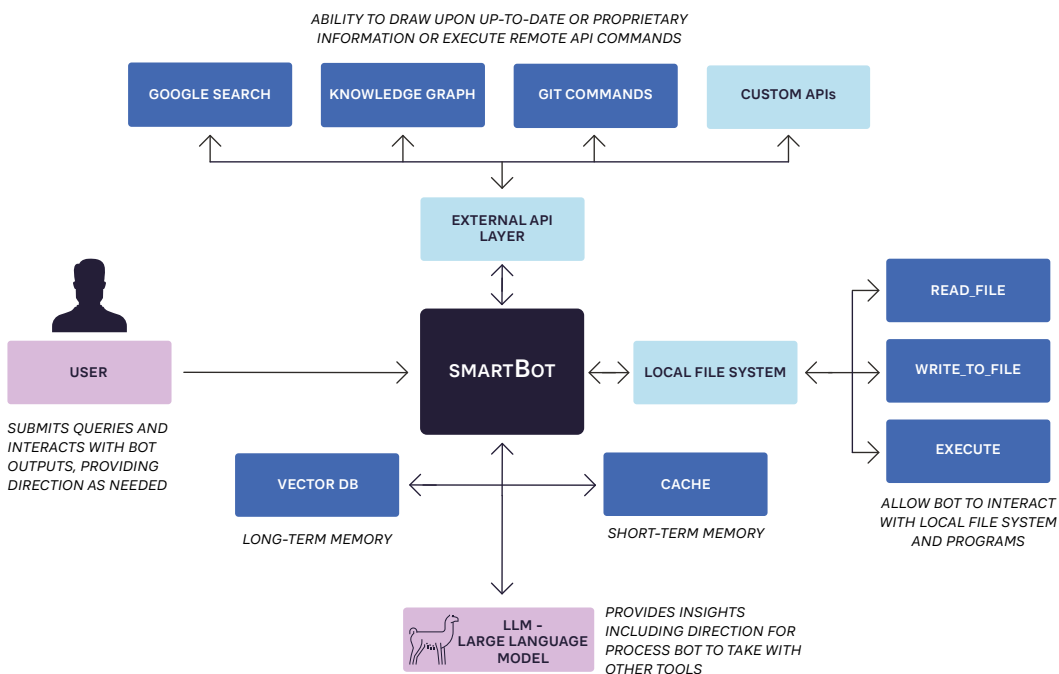
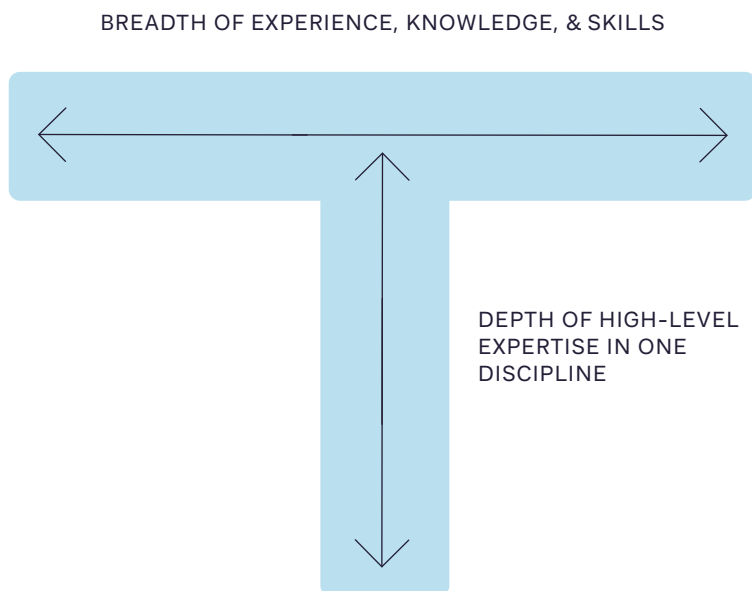


FIGURE 1: HIGH-LEVEL BOT ARCHITECTURE

It also avoids issues that could arise from the sudden imposition of regulatory restrictions. For instance, since the organization is fully aware of the data being used to fine-tune its model, it can satisfy any “right to forget” obligations by deleting the model fully and then retraining it without the infringing dataset.

Smaller base models also overcome training cut-off periods. They can be continually trained and fine-tuned by adding data from the organization itself using a variety of techniques such as Low Rank Adaptation (LoRA) or Quantized LoRA (QLoRA). This provides sufficient depth, as information is focused on the organization itself – rather than extraneous general knowledge that is irrelevant to normal business operations.

These factors all mean local internal models are best suited to corporate needs. They can be used to create powerful knowledge bots, intelligent assistants that help employees in specific areas. Essentially, these bots should be T-shaped, with deep knowledge and expertise in a single discipline. This means you may need multiple bots, each specializing in a particular subject.



**FIGURE 2: T-SHAPED SKILLED AI MODELS**

These locally running models don’t require wide knowledge bases and can focus on specific tasks, unlike larger models that need extensive knowledge. This not only improves their performance, but also makes them easier to train, maintain, and update, effectively providing smaller models with the ability to carry out the specific task that you’ve trained them for.

By being trained on specific datasets that incorporate the organization’s proprietary knowledge and industry-specific information, knowledge

bots will acquire a deeper and faster understanding of relevant terminology, jargon, and concepts. This enhances their search capabilities and delivers more accurate and relevant results. It also makes them much less likely to generate misleading or incorrect information, a major advantage in situations in which accuracy is paramount, such as medical diagnosis and legal advice.

## A PERSONALIZED APPROACH

Custom-trained knowledge bots can also deliver customized responses that cater to the unique requirements of each user in a way that generic LLMs can't. This personalization enhances user satisfaction and encourages greater engagement, fostering a strong

***CUSTOM-TRAINED KNOWLEDGE BOTS CAN ALSO DELIVER CUSTOMIZED RESPONSES THAT CATER TO THE UNIQUE REQUIREMENTS OF EACH USER IN A WAY THAT GENERIC LLMS CAN'T.***

“personal” partnership between employees and knowledge management systems. Users can interact with a bot using natural language queries, creating a conversational interaction that improves the experience and eliminates the need for complex search queries, technical commands, or

detailed training. If the user doesn't understand the initial answer, they can ask for it to be explained in a way that better meets their requirements.

As bots build their knowledge of users' preferences and previous interactions, along with the context within which they operate, they can act as intelligent information filters to ensure time and attention are directed onto not just the most productive tasks, but also the most important ones. For instance, a knowledge bot integrated into a project management system could identify potential roadblocks well in advance and provide proactive recommendations to keep projects on track.

## DEMONSTRATING THE PRODUCTIVITY GAINS FROM AI BOTS

One of the primary benefits of an effective knowledge bot should be that it improves productivity by providing the right information more rapidly than conventional approaches. However, given the rapid rise of generative AI, little published material exists to quantify the benefits when used internally within organizations.

Here at ADL, we therefore undertook a six-week pilot to determine the potential productivity improvements of AI used internally within an organization. We created a knowledge bot focused on the Atlantis Terraform automation tool, an expert solution that requires very

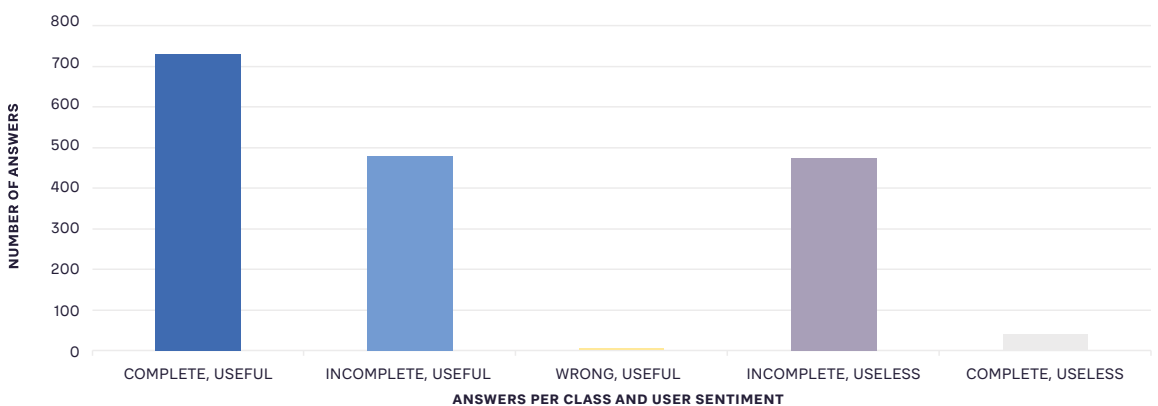
specific knowledge to operate. The bot was trained with all publicly available data (such as vendor product manuals), along with internal troubleshooting knowledge from users.

The bot was then released for pilot use by a team of 18 Service Reliability Engineers, all of whom use Atlantis significantly in their roles. The following methodology was used:

- Team members marked the bot’s answers as Complete, Incomplete, or Wrong.
- They then marked the answer as Useful or Useless.
- In the case of Useful answers, engineers estimated the time saved in five-minute increments.
- For Useless answers, 15 minutes were subtracted from the time-saving total. This was an estimate of the time wasted accessing the bot, forming the question, and waiting for the reply.

On average, the bot was asked 300 questions per week. Approximately 45 percent of responses were marked as Complete, whereas the rest were marked as Incomplete. Only a single answer was marked as Wrong across the entire experiment.

In an engineering setting, even Incomplete answers can be Useful – as they can help direct people to a solution to their problem. This led to



**FIGURE 3: RESULTS OF SIX WEEKS OF BOT Q&A**

70 percent of answers being marked as Useful, indicating an overall time saving.

Aggregating the results showed that, on average, approximately 40 hours of effort were saved each week – a nearly 10 percent productivity gain or the equivalent of employing one extra team member. In addition to delivering an immediate return on investment, this productivity gain is likely to increase over time, as:

- The system was new, and engineers were not required to use it.
- Processes were not changed to incorporate the bot.
- Users received minimal training – they were just asked to type their questions into the bot.
- Employees were still getting used to the bot and finding their own ways to make it work for them.

Additionally, the pilot involved a small, 18-person team of experts. Productivity gains will become greater as the use of knowledge bots is scaled up. For instance, it would add the equivalent of 10 people on a team of 180, leading to the potential for reallocating resources to do more with a lower headcount.

## UNDERSTANDING THE BENEFITS BEYOND PRODUCTIVITY

Besides the productivity benefits they bring, knowledge bots can deliver advantages in other areas:

- They **promote collaboration** across organizations by offering employees from different departments fresh insights through a company-wide knowledge base. This drives interdisciplinary collaboration, leading to development of new ideas and solutions that might not have emerged within isolated teams.
- Multilingual knowledge bots can **overcome language barriers** and promote diversity and inclusion within organizations by allowing employees from different countries and cultures to exchange knowledge on equal footing.
- Bots can serve as **virtual coaches or mentors**, providing personalized guidance and support to employees on their professional development journey.

## THE CHALLENGES TO ONGOING SUCCESS

For all the benefits custom-trained knowledge bots bring to organizations, they also introduce challenges that need to be understood and overcome, especially around the ethical implications of relying on AI to generate and disseminate knowledge. For instance, as with all AI, organizations need to be aware of the origin and accuracy of training data, even when generated in-house, and the consequent potential for misinformation and bias.

Transparency must therefore be a priority, especially in sensitive domains in which bot-assisted decisions must be documented and justified. This means humans need to be in the loop to provide accountability and ensure organizations operate within ethical boundaries and adhere to legal regulations.

The question of intellectual property rights and ownership of generated content must also be considered. As bots aggregate and synthesize information, sources and respect for intellectual property must be attributed, based on clear, established guidelines and procedures.

Additionally, employees may initially resist using bots for fear of losing status or even their jobs. Introducing custom-trained bots

will therefore require a well-thought-out change management strategy. Involving employees early on, clearly communicating the benefits of using bots, and providing training on how to get the best from them can do much to reduce concerns, as can encouraging employees

to continuously explore and experiment with their new personal assistant.

Finally, corporate knowledge changes rapidly. If custom-trained knowledge bots are to maintain their long-term usefulness, they need to be regularly fed with new data and insights so they evolve with an organization's needs. Techniques such as transfer learning, domain adaptation, and active learning can be employed to improve the bots' ability to learn and adapt to new information. Organizations should also put in place continuous monitoring and feedback loops to help identify and rectify any inconsistencies or inaccuracies in their outputs. Quality assurance processes, including human oversight and validation, ensure the generation of reliable and accurate information.

***THE QUESTION OF INTELLECTUAL PROPERTY RIGHTS AND OWNERSHIP OF GENERATED CONTENT MUST ALSO BE CONSIDERED.***

## INSIGHTS FOR THE EXECUTIVE – ACHIEVING COMPETITIVE ADVANTAGE THROUGH CUSTOMIZED AI BOTS

AI-powered bots are poised to transform knowledge management within organizations, delivering greater efficiency, productivity, and customer satisfaction, along with hyper-personalized learning experiences for employees.

Investing in custom-trained knowledge bots therefore has the potential to create a significant competitive advantage for a company by streamlining processes, improving operational efficiency, automating time-consuming activities, and accelerating workflows, as shown by our initial research. As technology continues

***THANKS TO AI, WE WILL ALSO SEE GREATER COLLABORATION BETWEEN HUMAN EXPERTS AND KNOWLEDGE BOTS, RESULTING IN THE CO-CREATION OF KNOWLEDGE.***

to evolve, these benefits will undoubtedly expand, transforming the way organizations access and use knowledge.

These productivity improvements can help create a significant competitive advantage in a dynamic business environment, as does

the faster, more accurate decision-making capability that knowledge bots underpin. However, in the future, the greatest differentiation may be from the bots' ability to generate insights and uncover valuable patterns from diverse and high-quality data.

Thanks to AI, we will also see greater collaboration between human experts and knowledge bots, resulting in the co-creation of knowledge. This combines the bots' capacity for data analysis with the unique insights, creativity, and contextual understanding of human experts.

As knowledge bots evolve, we could see bot-to-bot interactions, with bots collaborating and exchanging information as they solve complex problems. This would lead to networked intelligence within and between organizations.



To gain the benefits of AI within corporate knowledge management, CEOs should focus on:

- Understanding the AI market and going beyond tools such as ChatGPT when setting strategy and embracing opportunities. Look to bring AI development in-house using available base models
- Investing to develop the right skills and capabilities to build and optimize knowledge bots
- Focusing on foundational enablers such as security and compute power while ensuring that internal datasets are high quality and available for training and use
- Taking an ethical approach and ensuring that bots align with organizational goals and values, as well as involving employees to gain their buy-in
- Starting small, with pilot projects that have compelling use cases, and then growing to develop a range of T-shaped bots focused on specific subject areas

Overall, integration of AI-powered knowledge bots within organizations holds immense potential to transform knowledge management, empower employees, and drive organizational success in both the long and short term. Finally, the knowledge management challenge that organizations have been grappling with for decades is on the verge of being solved.



**NICHOLAS JOHNSON**

is a Partner in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

**MICHAEL PAPADOPOULOS**

is the Chief Architect in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

**FOIVOS CHRISTOULAKIS**

is a Consultant in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

**GREGORY BROWN**

is a Business Analyst in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

**ANASTASSIYA TIKHONOVA**

is a Business Analyst in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

**EYSTEIN THANISCH**

is a Business Analyst in Arthur D. Little's London office and a member of the Digital Problem Solving (DPS) Practice.

# SIMULATING STRATEGY



# THE REAL POTENTIAL OF THE INDUSTRIAL METaverse

## AUTHORS

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Dr. Albert Meige, Rick Eagar

**Is the Metaverse dead? With the same rapidity that it was hyped up only a couple of years ago, today it has fallen from grace. So far, most people have failed to get excited about the idea of spending large amounts of time withdrawn from the real world wearing clunky goggles. Now, it's all about artificial intelligence.**

So, should businesses just drop the Metaverse, or at least put it on the back burner, and focus on AI instead? Recent work by ADL's Blue Shift institute on the Industrial Metaverse – that is, metaverse applications for business, rather than consumers – strongly suggests that businesses would be unwise to do so.

In this article we explain what the Industrial Metaverse really means, its key building blocks, the business value it can deliver, and what companies should do about it. The summary provided here is based on a comprehensive Blue Shift study conducted in early 2023, comprising in-house research, client experience, and contributions from simulating interviews with experts across industry and academia. The full report is available at [www.adlitttle.com](http://www.adlitttle.com)<sup>1</sup>.

## WHAT'S NEW ABOUT THE INDUSTRIAL METAVERSE?

Most people understand that the Industrial Metaverse is concerned with the use of virtualization to conduct various industrial tasks better, aimed at delivering benefits such as greater operational efficiency and effectiveness, reduced costs, and better quality.

However, views differ about whether the Industrial Metaverse is a genuinely new concept, or instead just a new label for existing digital technologies under the Industry 4.0 umbrella that have been around for a long time (Figure 1).

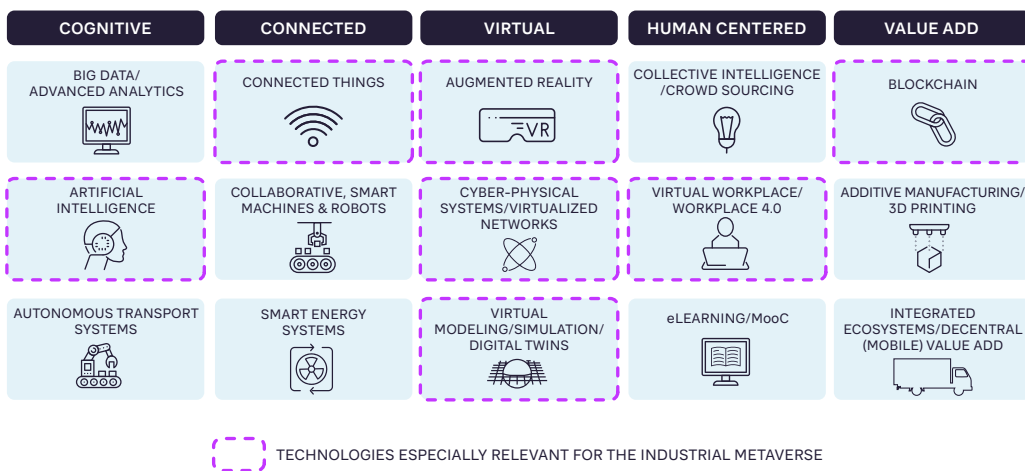
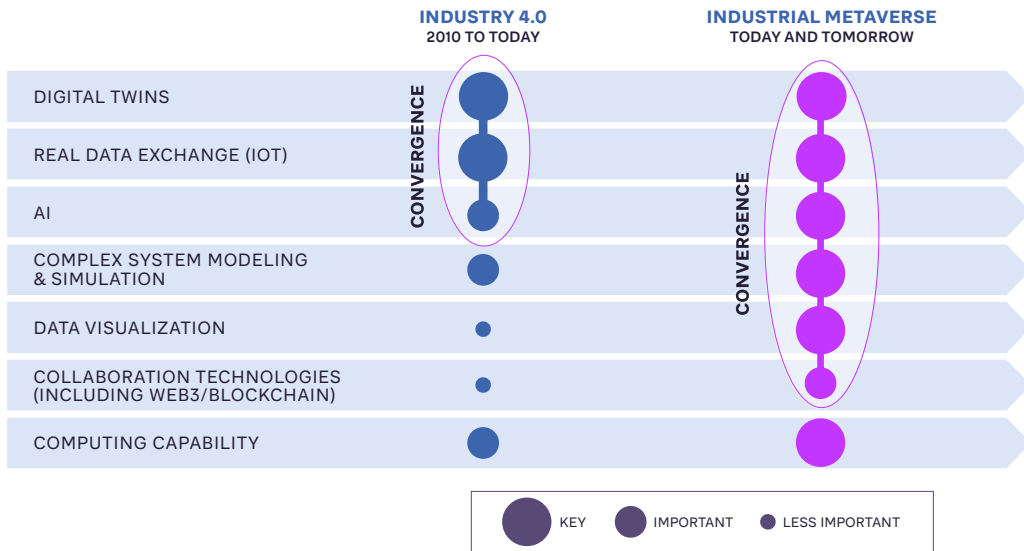


FIGURE 1: INDUSTRY 4.0 TECHNOLOGIES RELEVANT FOR THE INDUSTRIAL METAVERSE

Industry 4.0 refers to the “fourth industrial revolution,” and was first coined in 2015 to capture the transformational impact of cyber-physical systems. As shown in Figure 1, some of the technology blocks that are part of Industry 4.0 are also highly relevant for the Industrial Metaverse, including AI, connectivity, cyber/physical systems, blockchain, virtual workplace, and digital twins. In fact, virtual models, simulations, and digital twins of factories and plants have been around for nearly a decade, and digital design tools even longer. Virtual training, such as training for airline employees, is also well established. Significant improvements in productivity and efficiency, up to double-digit percentages, have been demonstrated in existing applications.

That said, implementation of Industry 4.0 is still by no means as widespread as was expected a decade ago. It faces several common barriers, including high upfront investment, difficulties in coordinating the required cross-functional transformation, challenges in data security and management, lack of available skills, and limitations imposed by legacy IT systems.

So, what's new about the Industrial Metaverse? What's new is a convergence of key technologies leading to a step-change in simulation capabilities (Figure 2).



**FIGURE 2: INDUSTRIAL METAVERSE TECHNOLOGY DEVELOPMENT AND CONVERGENCE**

Up until now, digital twins have been mainly limited to discrete products, components, plants, or factories. Use cases have been mainly targeted at operational and maintenance performance improvement. Further developments in simulation of complex systems, data visualization, and AI, combined with ongoing improvements in connectivity (IoT) and collaboration technologies, supported by increasing computing power, mean digital twins are now becoming possible for multiple connected facilities and systems.

This extends and elevates digital simulation from the level of operational improvements and design aids, towards becoming a key tool for strategic decision-making across complete systems – and ultimately across an entire global industrial enterprise.

Some early examples have already been shown: BMW's iFactory program involves simulation of potentially all its production facilities to enable a complete production strategy based around the use of digital twins for all production sites.

Perhaps even more impressively, Michelin has applied digital twinning together with complex system modeling to optimize its global sourcing strategy. (See Box 1.)

### **Box 1: Michelin: Evolving digital twins beyond plant level to optimize global sourcing strategy**

Michelin, the global tire manufacturer, has 70 production plants with operations in more than 170 countries and a growing number of product models. In 2021 the logistics cost was EUR1.9 bn. As Michelin's strategy is to manufacture products near the point of sale, global sourcing is a major challenge. Michelin was looking for a way to test different sourcing strategies and scenarios against each other to identify the best options, as well as ask "how-to" questions to help decide the best actions to optimize cost, quality of service, carbon footprint, and stock levels.

Although Michelin had used digital twins in product development for around 30 years, it had not applied the technology to sourcing, given the complexity of the global sourcing system with its multiple elements, relations, and nested subsystems.

Working with technology partner Cosmo Tech, Michelin built a complex systems digital model for global sourcing, including key indicators such as service levels, CO2 emissions, inventory, distribution, and plant capacity. This covered 1,700 product models, all within a complex manufacturing and distribution matrix. This "Simulation Digital Twin" allowed Michelin to run more than 80,000 simulations, each with more than 3,000 different and dynamic decision variables, and built-in optimization algorithms to determine the best strategy to adopt.

From this, Michelin was able to identify an actionable strategic sourcing plan for the next five years that would reduce its logistics costs by EUR10 million annually. This also optimizes the global profit margin by several percentage points and reduces transport and customs costs by more than 60 percent.

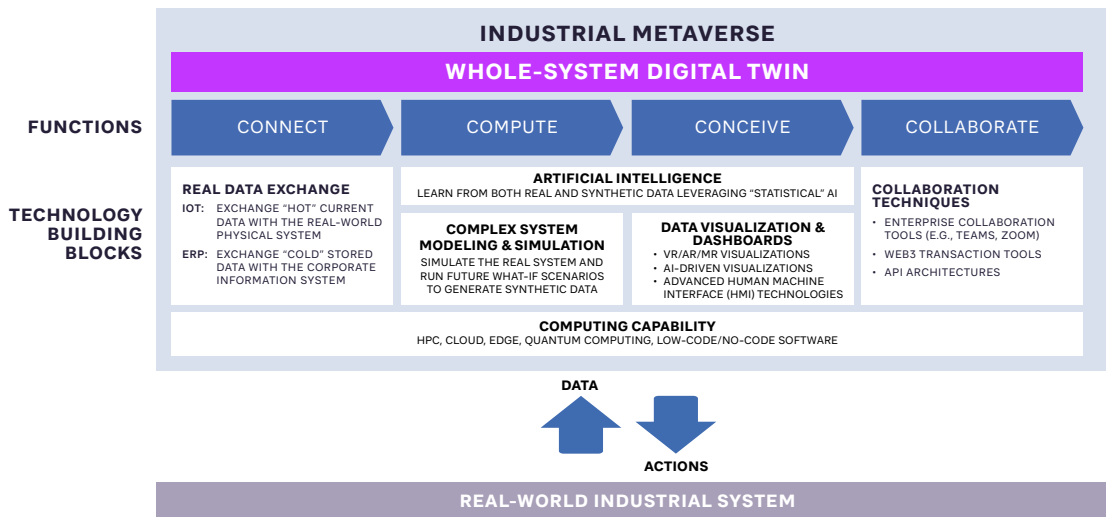
## **HOW BEST TO CONCEPTUALIZE IT**

Based on this idea of a step-change in simulation capabilities, we can usefully define the Industrial Metaverse as follows:

**"A connected whole-system digital twin with functionalities to interact with the real system in its environment, allowing decision-makers to better understand the past and forecast the future"**

Figure 3 shows its primary functional and technology building blocks.





**FIGURE 3: THE FUNCTIONS AND BUILDING BLOCKS OF THE INDUSTRIAL METAVERSE**

At the core is the **"whole-system digital twin,"** which ultimately could represent a complete end-to-end industrial system, including not just physical assets, but also processes, functions, resources, and organization. It would extend beyond the company boundaries to include relevant players and interactions across the whole company partner ecosystem, both upstream and downstream. It could also eventually include the broader environment within which the company operates. It needs to be constructed as a complex system to enable realistic and dynamic system behaviors to be modeled. Extensive "what-if" simulation functionality is a key part of the twin. Simulations are based on not just past data, but also present and future data.

Four key functions are necessary for the system to operate:

- **Connect:** The digital twin is permanently connected to the real-world system through the IoT (for "hot" current data) and ERP systems (for "cold" stored data). Real-time bidirectional connections enable continuous data collection and actuation back onto the system.
- **Compute:** The capability to process very large data volumes from the real system, including analytics, complex system modeling, pattern recognition, and simulation, to enable future scenario formulation.
- **Conceive:** Visualizing both physical and non-physical data, which may or may not be fully immersive. These visualizations interpret and present complex data in different ways, not only to simulate reality, but also to facilitate understanding and illustrate "what-if" scenarios.

- **Collaborate:** Functionality to enable a range of interactions, between internal staff, ecosystem partners, value chain players, customers, and others. Interactions may include commercial transactions as well as everyday co-working.

Figure 3 shows five key technology building blocks that enable this functionality, supported by a sixth computing capability technology block. These technologies, for the most part, exist already. However, further development is needed in all of them to deal with the increasing scale and complexity of data. Increased computing capability itself is a critical enabler for achieving very large, connected digital twin simulations.

Overall, the picture suggests a timescale of five+ years before true connected whole-system digital twins will be feasible, although in the meantime, intermediate steps involving digital twins of increasingly complex systems (such as the Michelin global sourcing example above) are still possible.

## WHY SHOULD COMPANIES PURSUE THE INDUSTRIAL METAVERSE?

### 1. CONVENTIONAL STRATEGIC DECISION-MAKING IS BECOMING INADEQUATE TO MEET THE COMBINED CHALLENGES OF COMPLEXITY, ACCELERATION, COGNITION, AND SUSTAINABILITY

The last few years have seen a mushrooming of complexity in industrial systems – for example, in the last two years alone, the volume of enterprise data has risen by over 40 percent to more than two petabytes, with vastly increasing partner network complexity. At the same time, the pace and unpredictability of change is accelerating. The limitations of human cognition mean making good decisions within these faster-moving, unpredictable systems is difficult. Even more importantly, sustainability imperatives mean end-to-end complex industrial system control is becoming increasingly important, for example, to manage Scope 3 emissions and develop strategies to achieve net-zero growth.

Conventional strategic decision-making is poor at meeting these challenges because it typically relies on oversimplification of complex systems. This means it often misses unexpected system impacts, and can be lagging rather than leading, failing to anticipate and react fast enough to rapid changes. The Industrial Metaverse offers the possibility of allowing companies to take informed C-level decisions based on a dynamic, forward-looking, whole-system approach. This would identify performance improvements and the impacts of change more rapidly and effectively, as well as help deliver on obligations to manage overall impacts and achieve sustainable growth.

## 2. THE BUSINESS BENEFITS OF THE INDUSTRIAL METAVERSE, EVEN IN THE SHORT-TERM, ARE SIGNIFICANT

As we have noted, even if fully connected, whole-industrial-system digital twins are some years away, organizations can still reap significant benefits from existing applications, many of which overlap with Industry 4.0.

Today's use cases can be split into four categories:

- **Optimization:** e.g., improvements in operation and maintenance, product quality, supply chain, and customer service
- **Training:** e.g., operational staff, safety, remote, and product training
- **Technical tools:** e.g., design/construction integration, asset inspection/maintenance, and remote troubleshooting
- **Management tools:** e.g., virtual meeting, collaboration, transaction, and interaction tools

**THE CURRENT INDUSTRIAL METAVERSE MARKET SIZE IS IN THE USD100-150 BILLION RANGE (DEPENDING ON HOW YOU DEFINE THE SCOPE).**

As digital twins extend beyond discrete plants towards industrial systems, the benefits will surpass productivity and efficiency to include the potentially much greater impacts of better strategic decision-making on overall growth, margin, and shareholder value.

## 3. THE INDUSTRIAL METAVERSE MARKET COULD ACCELERATE RAPIDLY IN A FIVE+ YEAR TIMEFRAME

Predicting when technologies will accelerate is always difficult. The sudden explosion of AI, together with advances in complex systems simulation, data visualization, and connectivity, could act as a catalyst. Importantly, unlike with the consumer Metaverse, adoption does not depend on acceptance of immersive virtual environments. Reflecting this key point, Apple's CEO, Tim Cook, prefers to use the term "spatial computing" rather than "Metaverse."

The current Industrial Metaverse market size is in the USD100-150 billion range (depending on how you define the scope). Our conservative forecast is that it will grow to around USD400 billion by 2030, although the upside could be more than USD1 trillion, with a CAGR in the 20-30 percent range.

## INSIGHTS FOR THE EXECUTIVE – WHAT SHOULD COMPANIES DO NOW?

Companies need to consider their strategy for the Industrial Metaverse in the context of their broader digital transformation journey. Organizations cannot easily “leapfrog” to full Industrial Metaverse implementation unless digitalization is already fairly mature. We suggest four steps:

### 1. REVIEW DIGITALIZATION STRATEGY, JOURNEY, AND POSITION

As a starting point, companies need to have a clear vision and pathway for their overall digitalization journey. Understanding the current position on the digitalization journey helps to determine:

- What still needs to be done in terms of digitalization basics before embarking on Industrial Metaverse development (such as data availability and infrastructure)?
- What is a realistic pace of development going forward?
- What would be a feasible target destination to align with the rest of the digitalization journey?

### 2. IDENTIFY VALUE-ADDING OPPORTUNITIES AND DEVELOP A ROADMAP

Many applications and use cases already exist. In developing the roadmap, companies should consider:

- What potential applications and use cases would add the greatest value? The initial applications for the Industrial Metaverse are likely to be operational, with an aim to extend towards more strategic applications over time.
- What is already technically feasible today, versus potentially feasible in coming years? As we have seen, although many feasible opportunities are currently available, large-scale complex industrial system simulations are still some way off.
- What is the vision and ambition for Industrial Metaverse applications in a five+-year time frame? The scale of ambition may depend upon the scale of digital transformation that companies are already committed to.

In developing the road map, companies should avoid overambitious detailed modeling at the start, as this could stifle early progress. As well as the use cases themselves, the roadmap should consider what new processes are needed to access, update, analyze, interpret, and act upon the required data.

### **3. IMPLEMENT PILOTS, ADOPT A TEST-AND-LEARN APPROACH, AND MANAGE CHANGE PROACTIVELY**

An agile and responsive test-and-learn approach will work best. This means starting small and selecting initial pilot projects that are readily replicable, with relatively short payback times that do not need extensive involvement from external stakeholders. Managing the people impacts of implementation is key, for example, new roles and skills requiring support over an extensive period.

### **4. BUILD AND ALIGN THE PARTNER ECOSYSTEM, CREATING A WIN-WIN**

The major benefits of the Industrial Metaverse are realized through involving not only internal operations, but also the partner ecosystem. This requires sharing of much more data than is traditionally shared

***THE MAJOR BENEFITS OF THE INDUSTRIAL METAVERSE ARE REALIZED THROUGH INVOLVING NOT ONLY INTERNAL OPERATIONS, BUT ALSO THE PARTNER ECOSYSTEM.***

between commercial partners, which demands a new mind-set and culture. Mutual benefits should be clearly demonstrated – such as faster customer response, reduced working capital, smoother customer/supplier interfaces, and better

management of sustainability impacts. Data management standards and adequate safety and security are also key.

The Industrial Metaverse has tangible business value beyond the hype. Executives should not write it off just yet.



**DR. ALBERT MEIGE**

is the Director of Arthur D. Little's Blue Shift Institute.

**RICK EAGAR**

is a Partner Emeritus of Arthur D. Little.

# RETHINKING PRODUCT CONNECTIVITY







**HOW DATA CAN  
TRANSFORM SERVICES  
AND CUSTOMER  
EXPERIENCE**

## AUTHORS

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Johan Treutiger, Dr. Michael Opitz, Agron Lasku, Ossian van Arkel, Axel Leth

**In a data-driven world, product manufacturers have a stark choice – either digitize to become more flexible and customer-centric or be sidelined by nimbler competitors. They need to embrace the transformative opportunities that data and the Internet of Things bring to add value to their offerings and change their business models.**

All businesses understand the vital importance of collecting, analyzing, and acting on data to enable:

- New business models, such as offering as-a-service or outcome-based pricing, and entering the Industrial Metaverse
- Greater innovation through new services that create new revenue streams
- An improved customer experience

Product connectivity is the foundation of successful data-driven business models for product manufacturers, enabling access to the right data at the right time. Yet, adding a digital layer to physical products is challenging at a strategic level, requiring close coordination with overall digital strategy; new, multidisciplinary capabilities; and deep understanding of a complex, fast-changing product/supplier ecosystem.

Connectivity has to be driven by a digital strategy, not technical considerations. However, many organizations struggle to define and agree their digital ambitions, which holds back necessary transformation.

How can business leaders overcome these challenges at a strategic level and become data-driven – before rivals seize the opportunity? This article explains how to reap the benefits of seamless, transformative product connectivity to digitalize how companies operate.

# OPERATING IN AN EVER-MORE CONNECTED WORLD

Product connectivity is not new, but often has not been handled strategically or holistically by organizations or linked to digital strategy. As data and digitization become central to company strategies, this must change, demanding an overarching approach to product connectivity.

## AN ACCELERATING MARKET

The Internet of Things (IoT) is becoming table stakes for product manufacturers. Ninety-nine percent of companies in ADL's 2022 IoT survey have either implemented or are piloting product connectivity, with 48 percent increasing their spend year on year<sup>1</sup>. Altogether 6.6 billion IoT devices are expected to be connected globally by 2031, as shown in Figure 1.

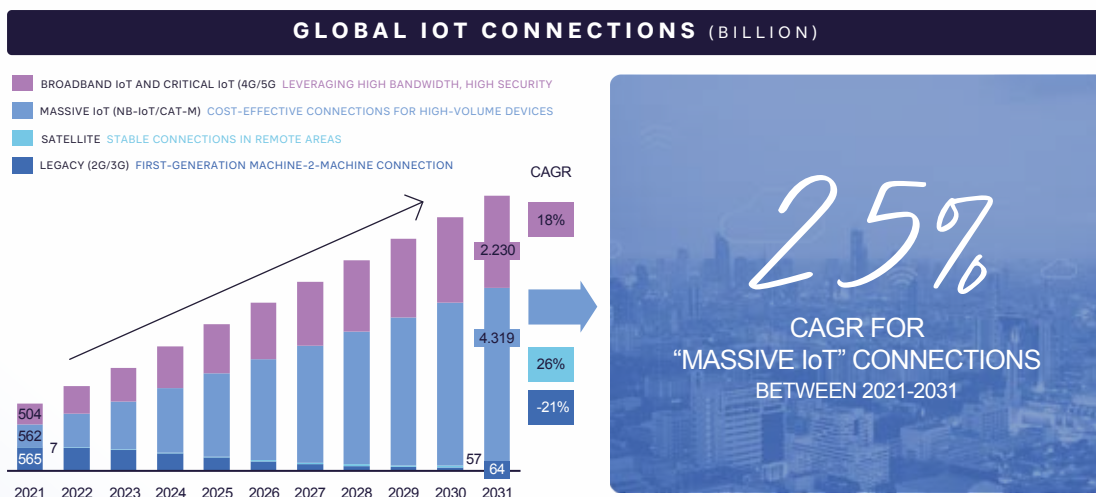


FIGURE 1: GLOBAL IOT CONNECTIONS (SOURCE: GARTNER, ARTHUR D. LITTLE)

### 1. The opportunities of connectivity

Product connectivity underpins transformation through the timely collection and sharing of data. It delivers opportunities in four areas:

### 2. Creating new business models

Seventy-five percent of companies surveyed by ADL see product connectivity enabling new working models. These include “as a service” business models, new revenue streams based on product data and outcome-based models, as described in *Selling customer outcomes – A business model transformed* (Prism S1 2022). For example, Hitachi’s Lumada IoT platform connects its products and systems, from industrial machinery and trains to IT systems. This enables it to offer new services to clients globally.

1. The ADL 2022 Internet of Things study surveyed global CXOs from the automotive, transport and logistics, manufacturing, and energy and utility sectors.

### 3. Enabling a better customer experience

Seventy percent of businesses in the ADL study said connectivity was key to meeting changing customer requirements. For example, Ericsson, telematics provider ZF, and Orange Belgium introduced a new truck and trailer monitoring and driver assistance service for freight companies. Together these provide cost savings of EUR 876,000 for a mid-size truck transport company, 6 percent of total annual spend.

### 4. Greater efficiency

Data increases efficiency by enabling predictive maintenance, reducing downtime, and optimizing operations. For example, Caterpillar's Cat Connect solution uses the data from technology-equipped construction vehicles to enable predictive maintenance while providing greater insight into customer operations.

### 5. Future innovation

Product data can be used to train AI algorithms and carry out in-depth analytics to predict the future and create new products and services. Demonstrating the benefits, food company Farmer's Fridge has deployed a network of smart fridges stocked with fresh meals. Fridges are restocked based on an algorithm that learns customers' food preferences, reducing waste and increasing satisfaction by supplying what people want to eat.

#### Box 1: Sony Visilion

Sony's Visilion service uses LTE-M IoT connectivity to track assets, such as equipment and cargo, in real time. Visilion increases efficiency, reduces costs by optimizing transit times, and delivers greater protection against theft or loss with alerts for route deviation, geo-fencing, and detecting shock anomalies.

Visilion delivers benefits to multiple sectors. Healthcare customers have been enabled to find equipment immediately, increasing efficiency and allowing better patient care. Industrial companies have improved productivity by using data to verify workflow assumptions, while logistics providers are able to future-proof their value chain, strengthen customer service, and build trust by providing detailed, real-time information about deliveries.

## THE CHALLENGES TO STRATEGIC CONNECTIVITY SUCCESS

Multi-product manufacturers face multiple challenges to creating and deploying a successful product connectivity strategy:

### THE NEED TO LINK TO DIGITAL STRATEGY

Connectivity decisions need to start, and flow from, the company's digital strategy. Defining digital strategy and ensuring buy-in is therefore vital, but can be difficult for manufacturers that are used to operating in an analog world. They need to add new competences, ways of working, and change culture to become digital-first across the organization. Additionally, businesses need to effectively define the value proposition and logic for incorporating connectivity into their products in order to unlock investment. This can be challenging in that traditional ROI calculations might not show value, as returns come in the form of difficult-to-quantify new opportunities.

### A COMPLEX, FRAGMENTED, AND FAST-EVOLVING SUPPLIER LANDSCAPE

Complexity leads to the wrong technology choices being made (such as around connectivity type, sensors, IoT platform, and applications). The risk of making the wrong choice around suppliers and technology

not only is expensive, but potentially limits future options and undermines opportunities for value creation. Companies also need to strike the right balance between the differing lifetimes of products and the connectivity technologies deployed within them, and understand the trade-offs between adopting off-the-

**MULTI-PRODUCT MANUFACTURERS FACE MULTIPLE CHALLENGES TO CREATING AND DEPLOYING A SUCCESSFUL PRODUCT CONNECTIVITY STRATEGY.**

shelf products versus investing in more specialized products built to their requirements. Sixty-nine percent of respondents in ADL's IoT Market Study mentioned that the high complexity of implementing solutions was a key challenge with the IoT, while 38 percent said they had difficulties in justifying the business case around IoT investments.

### THE REQUIREMENT FOR NEW CAPABILITIES

Adding product connectivity requires new digital capabilities, partnerships, and skills. Companies must create new ecosystems and teams to provide the organization and resources to manage and integrate product capabilities at a strategic and company-wide level. Aircraft manufacturer Airbus partnered with Palantir Technologies to create its Skywise data platform, which uses IoT sensor information for predictive maintenance, monitoring, and benchmarking of aircraft fleet performance.

## BALANCING BUSINESS UNIT AND OVERALL REQUIREMENTS

Companies providing multiple product types must meet the differing connectivity needs of every business unit and product that they supply. Equally, they must balance departmental needs with corporate standards to ensure economies of scale and efficient access to consistent, high-quality data. This requires a portfolio approach, rather than expecting one connectivity solution to meet every requirement.

## DIFFERING STANDARDS AND REGULATIONS ACROSS THE GLOBE

Wireless standards vary between markets, for example, with LTE-M dominant in the US and NB-IoT most used in China. This requires organizations to make strategic choices, particularly in light of geopolitical concerns between the US and China, especially around cybersecurity. Fifty percent of companies surveyed mentioned that security concerns were a key challenge with connectivity and the IoT.

On the regulatory side, businesses need to navigate a thicket of different legislation put in place by the EU (such as the EU Radio Equipment Directive Delegated Act on Cybersecurity) and the US (at both a federal and state level – California and New York have created cybersecurity regulations, for example). Cybersecurity also ties into customer concerns and requirements around protecting personal data and meeting security standards.

## EMBRACING THE CONNECTIVITY OPPORTUNITY

Product manufacturers need to put in place a holistic strategy to fully embrace the connectivity opportunity and the transformational benefits it potentially delivers. This requires a focus on understanding the ecosystem and then building a strategy based on the specific needs of the company and its current and future customers.

There are three groups of themes for companies to understand:

### 1. TECHNOLOGY THEMES

The proliferation and emergence of different connectivity technologies and standards enables new use cases. However, it also creates more choices and decisions for both companies and customers as they look to cover all products and regions.

Companies must choose carefully which platforms to create compatibility with. Nearly two-thirds (65 percent) of companies in the ADL IoT study pointed to difficulties with technical integration as a key challenge to connectivity success.

## 2. REGULATORY THEMES

The growing importance of cybersecurity will affect manufacturers profoundly. Failing to keep connected products secure impacts reputation, leads to legal/regulatory challenges, and can ultimately provide a backdoor into corporate systems. A focus on cybersecurity must run through ways of working and product design, covering areas such as vulnerability and data management, continuous over-the-air (OTA) updates, and usage of open-source code or products from partners.

Allied to cybersecurity, growing US/China tensions around technology mean that global companies will need to develop a portfolio of regional solutions. To mitigate risk they should develop tools that enable them to understand the compliance burden of specific features being integrated into their products in specific regions.

## 3. BUSINESS THEMES

Product connectivity is considered a standard feature due to increasing customer adoption and the fact that data is becoming a critical business resource. Manufacturers have no option but to

integrate it within products, despite it being challenging to measure ROI at a business level.

***FAILING TO KEEP CONNECTED PRODUCTS SECURE IMPACTS REPUTATION, LEADS TO LEGAL/REGULATORY CHALLENGES, AND CAN ULTIMATELY PROVIDE A BACKDOOR INTO CORPORATE SYSTEMS.***

Connectivity therefore needs to be built on overall digital strategy. Companies must create future-proof data competencies and connectivity infrastructure built on their digital foundations.

They need to develop and

define what data is needed and why, including for R&D and innovation purposes alongside existing business cases. For example, automotive company Hyundai has invested heavily in software development to create its Bluelink connected car operating system, which includes telematics and remote start features.

By understanding these themes and answering three key questions – why, what, how – manufacturing companies can transform their business models, services, and customer experience through effective product connectivity.

## WHY DOES MY COMPANY STRATEGY REQUIRE CONNECTIVITY?

First, companies must define why they require connectivity in their products as part of their digital strategy. This will vary depending on:

- Their desired position in the market
- Their value proposition for end users
- Which digital solutions can be enabled through connectivity to deliver this value proposition
- How connectivity can be used to disrupt existing business models
- Particular use cases and the data each of these require
- The best business model(s) to capitalize on this value proposition

## WHAT CONNECTIVITY TECHNOLOGIES DO WE NEED FOR THE FUTURE?

When the “why” is defined, the “what” can be created, in terms of connectivity technologies and sensors that enable the desired use cases and value propositions.

Every product may have different requirements (Figure 2). Companies should therefore define a portfolio of applicable technologies for business units to choose from. A one-size-fits-all approach will not deliver sufficient value. However, this needs to be balanced against corporate standards and achieving economies of scale. Companies must focus on factors such as:

- Ensuring interoperability and ease of integration
- Aligning connectivity requirements with customer experience goals
- Building a device and connectivity management strategy
- Evaluating the cost/benefit of retrofitting the installed base. This could potentially cover millions of sensors in brownfield implementations





SPECIFICATIONS OFFERED BY CONNECTIVITY												
CONNECTIVITY PARAMETER	SHORT RANGE			CELLULAR				LPWAN		SATELLITE		WIRED
	BLE	WiFi	THREAD	5G RECAP	LTE CAT-1	LTE-M	NB-L0T	LORA	SIGFOX	LEO	GEO	
BANDWIDTH	MEDIUM	HIGH	LOW MEDIUM	HIGH	HIGH	MEDIUM	LOW MEDIUM	LOW	LOW	LOW/HIGH	LOW/HIGH	HIGH
PRICE PER MODULE	\$	\$	\$	\$	\$	\$	\$	\$	\$	-	-	-
RANGE												NA
POSITION FOR FUTURE												

FIGURE 2: CONNECTIVITY OPTIONS AND PARAMETERS

## HOW DO WE BUILD THE CAPABILITIES NEEDED TO DELIVER CONNECTIVITY?

When the “why” and “what” are defined, decisions can be taken around how capabilities are built and deployed. This requires a transformational change to ensure that the resources, skills, and digital-first ways of working are in place to ensure success.

### BUSINESSES SHOULD:

- Build an organization ready to support millions of connected devices
- Further integrate connectivity into product development and create the ways of working needed to maximize value
- Explore how to integrate data into the business model and product development
- Find and manage a network of new partners to support connectivity
- Ensure compliance with the complex regulatory landscape
- Evaluate whether the wider IT stack is fit for future needs
- Work to safeguard connectivity investments even if ROI discussions are initially challenging

### **Box 2: Building a strategy for global connectivity**

An industrial manufacturer with a wide range of long-lifetime electromechanical products wanted to increase revenues from digital services to better compete with rivals. It knew that achieving success required a stronger digital offering, including more efficient, group-wide data collection and a strategy to effectively exploit data across its business.

To help support the development of a detailed business vision and connectivity plan that covered its medium-term needs across departments up until 2030, it decided to conduct a deep-dive investigation into the current state of connectivity and the individual needs of its business units, with support from Arthur D. Little.

The resulting robust, company-wide connectivity strategy particularly helped decisions around whether connectivity modules would be integrated or plugged into particular products, where to invest, how to meet differing global regulatory standards, and required operational model changes, as well as optimizing decisions around which connectivity portfolio options to choose. Overall, the project moved the importance of connectivity up the management agenda, reduced risk, and increased the likelihood of overall digital success.

## INSIGHTS FOR THE EXECUTIVE

- Connectivity decisions may seem technical and tactical. However, given the importance of data to building new business models and services and the cost of incorrect choices, strategy must be driven from the top. Start with digital strategy.
- Adopt a portfolio approach to cover all business unit needs and unify business units behind choices.
- Ensure a clear link between the connectivity and data strategies, business model, and customer experience. Leverage connectivity opportunities across the organization - in product development, new business models, skills and resources, and future strategy.
- Understand and plan for the potential impact of current and future regulation, particularly around how geopolitical rivalry may limit technology choices in specific markets.
- Participate strongly in relevant ecosystems, orchestrating other players where appropriate.
- Act now, moving quickly to seize opportunities before competitors do.



**JOHAN TREUTIGER**

is a Partner in Arthur D. Little's Stockholm office and the Head of the Strategy & Organization Practice in the Nordics.

**DR. MICHAEL OPITZ**

is a Partner in Arthur D. Little's Munich office and the Head of the Telecommunications, Information, Media and Electronics (TIME) Practice in Central Europe.

**AGRON LASKU**

is a Partner in Arthur D. Little's Stockholm office and the Head of the Telecommunications, Information, Media and Electronics (TIME) Practice in the Nordics.

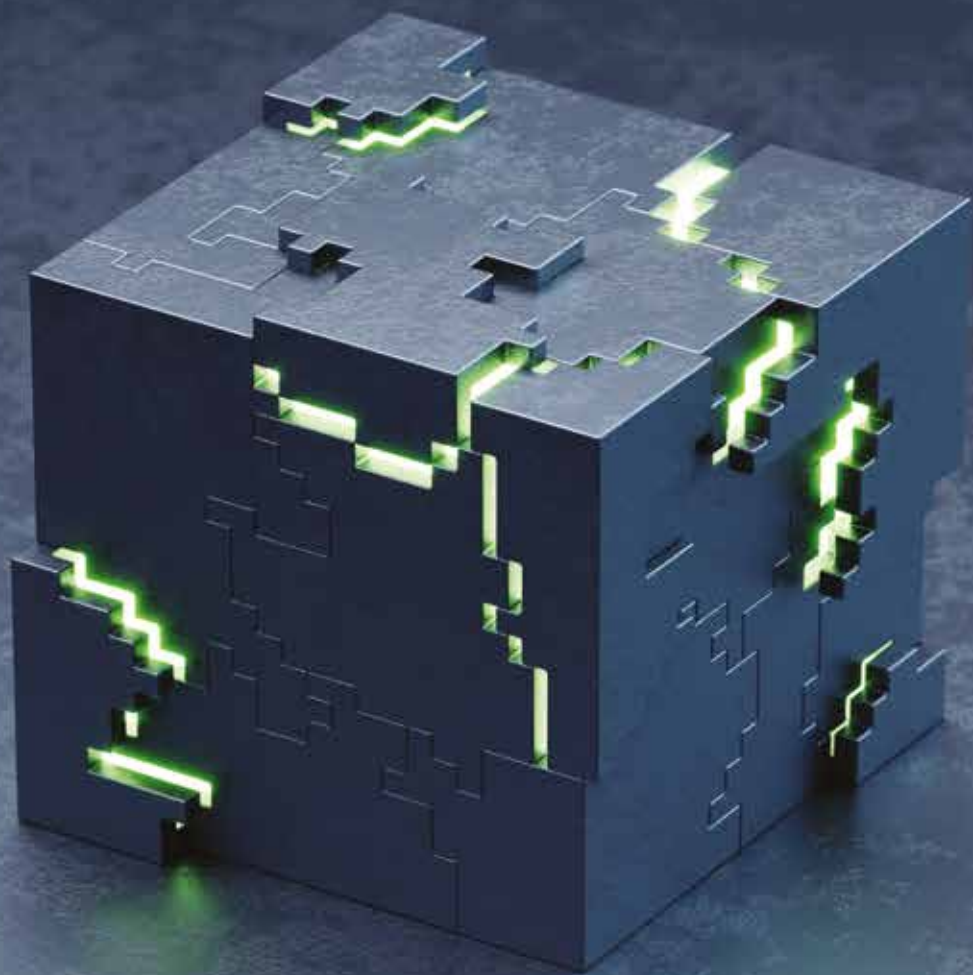
**OSSIAN VAN ARKEL**

is a Consultant in Arthur D. Little's Stockholm office and a member of the Telecommunications, Information, Media and Electronics (TIME) Practice.

**AXEL LETH**

is a Business Analyst in Arthur D. Little's Stockholm office and a member of the Strategy & Organization Practice.

# SMALL MODULAR REACTORS – THE MISSING PIECE IN THE ENERGY TRANSITION PUZZLE?



## AUTHORS

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Lars Thurmman-Moe, Benedikt Unger, Michael Kruse,  
Fredrik Pedersen, Andreas Dobloug, Stian Rød

**Small modular reactor (SMR) technology has been attractive on paper, but difficult to realize in practice. Despite high investments into SMR development, no SMRs are yet in commercial operation. However, as the world struggles with the immense challenges of transitioning away from fossil fuels, a resurgence of interest has appeared across the globe.**

Are SMRs finally reaching the stage at which they could become a key part of the energy solution? In this article we look at the background of SMRs, their benefits and challenges, and why now could be the right time to build an effective ecosystem to help move them from paper to reality.

## DEAD IN THE WATER?

Originally, nuclear energy was seen as cheap, “clean,” and stable. However, disasters such as Three-Mile Island, Chernobyl, and Fukushima understandably led governments and the public to reconsider. The serious consequences of these accidents led to rapid decisions to decommission nuclear programs before their expected lifespan. Anti-nuclear sentiment led to a decline in nuclear’s share of global energy production, from 17 percent in the mid-1990s to approximately 10 percent today.

In addition to this, the tale of nuclear energy in recent years has been messy and troublesome, with difficult issues regarding waste disposal, security threats arising from nuclear energy as a potential target for terrorist attacks, and, most visibly, huge cost overruns and significant delays. For example, the construction of two large modern reactors (EPR-1600s) at Hinkley Point C in the UK was originally estimated to cost GBP16bn and commence commercial operations by 2025.

In February 2023, EDF announced that its cost was likely to increase to GBP32.7bn and completion would be delayed to September 2028 at the earliest – an astonishing approximate 100 percent cost overrun and a three-year delay. Some observers have concluded that the safety and economic risks of large-scale nuclear power generation are simply too great to take on.

## THE ATTRACTIONS OF SMRS

Small reactors date back to the early years of the nuclear power industry. Built in the USSR, the US, and European countries during the 1950s to 1970s, these early small reactors were originally used for military purposes in submarines and aircraft carriers. Small reactors generally suffer from poor economies of scale versus large nuclear power plants (LNPPs), which are generally at least 700MW – enough to power a city the size of Madrid. However, SMRs can circumvent the economic disadvantages by utilizing modularity to reduce capital investment. Furthermore, streamlined production and certification in factory environments can significantly reduce construction and deployment timelines.

SMR deployment is significantly more flexible than that of legacy reactors. LNPPs in the US have an 800 km<sup>2</sup> emergency planning zone (approximately the size of San Diego), and SMR developers argue that their safety zones will be equal to that of the site boundaries. Additionally, the small capacity of SMRs facilitates off-grid deployments, which unlocks new use cases, such as on-site power generation for industry.

***FROM AN INVESTOR PERSPECTIVE, SMRS HAVE SUBSTANTIALLY LOWER UPFRONT INVESTMENT REQUIREMENTS, WHICH OPENS A NEW PROPOSITION FOR NUCLEAR ENERGY FOR SMALLER INVESTORS.***

From an investor perspective, SMRs have substantially lower upfront investment requirements, which opens a new proposition for nuclear energy for smaller investors. This increases the total capital pool for nuclear, putting less strain on local governments and

municipalities, and increasing adoption further. Additionally, lower project complexity and shorter deployment timelines can alleviate cost and schedule risks of nuclear new-build projects.

While for some, the perceived safety, security, and environmental risks of nuclear fission power of any sort remain unacceptable, for many others, including many governments around the world, SMRs appear to offer an effective way to help meet the needs of baseload power generation without the downsides of constructing and operating LNPPs.

## WHY AREN'T SMRS ALREADY DEVELOPED?

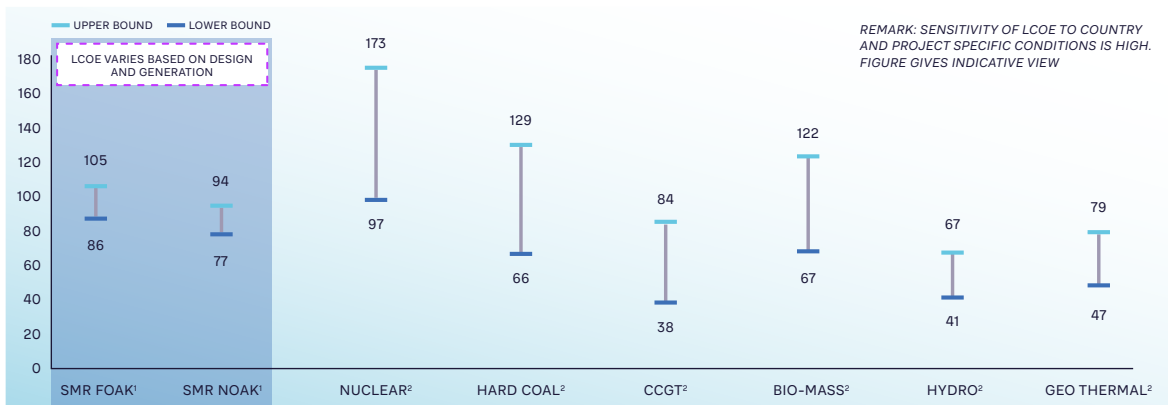
Given the appeal and long history of small reactors, questioning why no SMRs are in operation is reasonable. In fact, SMRs are not expected to begin commercial operation until the end of this decade, with currently only a few technologies nearing commercialization. Most SMRs are still in the conceptual stage, making it difficult to assess their commercial viability without further development,



testing, and deployment. As Admiral Hyman Rickover, a pioneer of the US nuclear industry, told the members of Congress in 1957: “Any plant you haven’t built yet is always more efficient than the one you have built. This is obvious. They are all efficient when you haven’t done anything on them, in the talking stage. Then they are all efficient, they are all cheap. They are all easy to build, and none have any problems.”

The slow development of SMRs can be attributed to several challenges faced by the nuclear energy industry. Over the years, the operating costs of LNPPs have increased, while new projects have encountered delays and cost overruns. The costly process of uranium mining and lack of a viable nuclear waste storage solution have added complexity. A dwindling workforce due to long gaps between reactor builds, as well as rising interest rates impacting financing, have also led to under-prioritization and undermined development efforts in nuclear energy.

Additionally, the sheer complexity of SMR technology development has been a hurdle for developers and vendors alike. To make an SMR cost-effective requires breakthrough innovation in reducing capex and opex to obtain a reasonable levelized cost of electricity (LCOE). In their current state of development, SMRs do not yet represent a commercially competitive energy source. However, when we look at the power generation technologies that offer similar reliability to that of SMRs, the competitiveness becomes more apparent <sup>1,2</sup> (Figure 1).



**FIGURE 1: LEVELIZED COST OF ELECTRICITY FOR SMRS VERSUS OTHER POWER GENERATION TECHNOLOGIES**

1. Arthur D. Little analysis (bottom-up)  
 2. Lazard (2021), Arthur D. Little analysis (bottom-up)  
 Note: FOAK: first-of-a-kind; NOAK: Nth-of-a-kind; CCGT: combined cycle gas turbine; average exchange rate USD-EUR for 2021 applied to LCOE data from Lazard study

## WHY SMRS ARE A HOT TOPIC NOW

Today's global energy markets are facing a disruption of Schumpeterian proportions as the gale of decarbonization upends the status quo of fossil fuel power generation. Dismissing nuclear was easier in the post-Fukushima years, when many attractive alternatives were available. Renewables were growing fast and becoming more affordable, while natural gas was clean enough and readily available. However, increasing prices in recent years, combined with a strong emphasis on security of supply and stable electricity provision, have transformed the outlook. Moreover, the intermittent nature of energy being generated through renewable sources, combined with issues such as land use efficiency, network costs, and grid efficiency, means other energy sources are also needed to accelerate the green shift further. Nuclear remains one of the few options available for stable baseload power.

The Russian invasion of Ukraine and consequent massive supply-side disturbance have underlined the message for world leaders that energy security is of ever-increasing importance in a volatile geopolitical environment. Traditional, non-renewable energy sources such as coal, oil, and gas still account for the majority of the world's

***TRADITIONAL, NON-RENEWABLE ENERGY SOURCES SUCH AS COAL, OIL, AND GAS STILL ACCOUNT FOR THE MAJORITY OF THE WORLD'S ENERGY CONSUMPTION.***

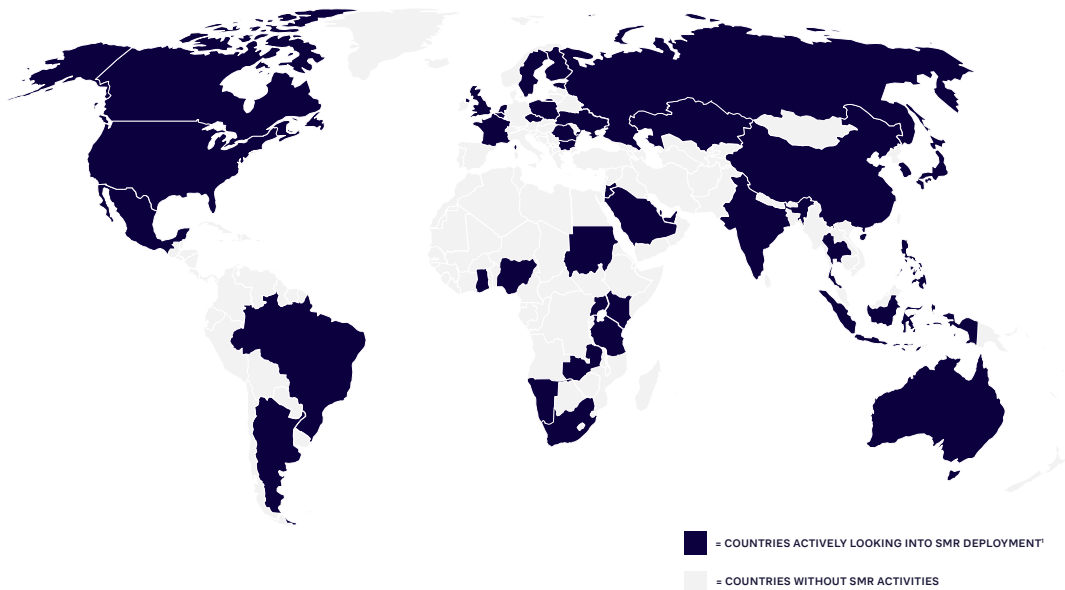
energy consumption. For non-producing countries, this entails heavy reliance on imports, as stockpiling these types of fuels for more than a few months of consumption far exceeds total storage capacity.

Stable and well-functioning supply chains are thus paramount to ensure dependable energy access, and the shortcomings of excessive reliance on imports have become apparent with recent developments. As nations around the world are realizing the need for reduced dependency on energy imports in order to hedge against sudden supply shocks, nuclear energy is starting to become more attractive as a potential alternative. The energy density of nuclear fuel is far superior to that of other sources, with one uranium fuel pellet (the size of a fingertip) containing as much energy as 1 ton of coal, 3.5 barrels of oil, or 4,800 cubic meters of natural gas<sup>3</sup>. For a 1,000MWe nuclear power plant, daily consumption of fuel is just over 3 kgs. In comparison, a coal-fired power plant with similar capacity burns around 10,000 tons per day.

As nuclear becomes somewhat more palatable for a public faced with increasing energy prices and governments looking to secure energy autonomy, SMRs are increasingly being considered as an attractive alternative over traditional nuclear, either in themselves or as a bridge towards the next generation of nuclear reactors.

## WHO IS LEADING THE WAY

The number of countries publicly expressing their intent to deploy SMRs in the near- to mid-term has been increasing steadily. Currently, more than 30 countries have a vested interest in SMRs, either through development or potential deployment of the technology. Unsurprisingly, countries with the most nuclear experience are leading the way in SMR deployment. However, even countries that have no nuclear experience are turning their attention to SMRs, such as Poland, Saudi Arabia, and Estonia.



### COUNTRIES LOOKING INTO SMR DEPLOYMENT<sup>1)</sup>:

Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Estonia, Finland, France, Ghana, India, Indonesia, Japan, Jordan, Kazakhstan, Kenya, Mexico, Namibia, Netherlands, Nigeria, Philippines, Poland, Qatar, Romania, Russia, Saudi Arabia, South Africa, South Korea, Sudan, Sweden, Tanzania, Thailand, UAE, Uganda, UK, Ukraine, US, Zambia

<sup>1)</sup> Countries that have an agreement in place with a technology vendor, have a publicly funded program assessing SMRs for their energy mix, or have publicly stated their interest

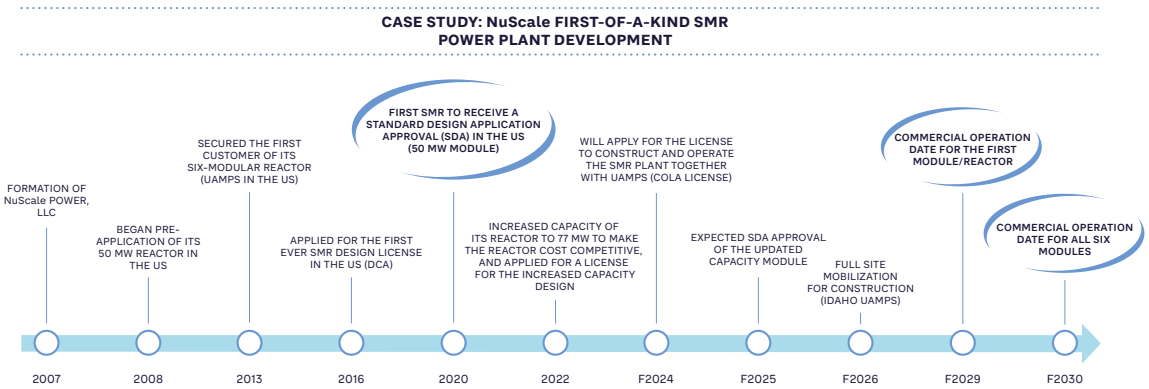
**FIGURE 2: COUNTRIES LOOKING INTO SMR DEPLOYMENT**

The SMR space is crowded with more than 80 different technologies under development, each with its own unique features. As the industry evolves, a large number of these technologies will fail, and a few leaders will prevail. Some common characteristics are associated with success:

- **Governmental support:** Financial support from governmental institutions is a key success factor for a technology vendor, as the R&D phase of an SMR design is cash intensive. Vendors in countries with predictable and experienced policy makers, such as the NRC in the US, the CNSC in Canada, and the ONR in the UK, will also have an advantage.

- **First-mover advantages:** First-of-a-kind (FOAK) reactors are often considered to be riskier and more troublesome than Nth-of-a-kind reactors (NOAK). Hence, vendors that have successfully deployed their technologies are likely to receive more business than those that come later to the market.
- **Traditional versus experimental technologies:** The market consensus is that customers, especially utilities, prefer traditional and tested technologies (light-water reactors) over experimental technologies that require policy changes.
- **Vendor robustness:** The perceived robustness of the vendor will be an important factor. Companies with established nuclear and engineering backgrounds are likely to have a natural advantage (such as GE Hitachi, Holtec International, and others).
- **Supply chain robustness:** Having an established supply chain with strong nuclear manufacturing experience will be important to build customer confidence, given the previous history of cost overruns and delays.

One of the possible contenders for first SMR to market is, however, NuScale, originally established in 2007 in Oregon, which is predicting its first commercial operation in 2029 (Figure 3).



**FIGURE 3: NuScale SMR DEVELOPMENT TIMELINE**

## THE IMPORTANCE OF BUILDING THE ECOSYSTEM

To enable SMRs to overcome development challenges and fulfill their potential in the energy transition, creating the right environment is crucial. In the 20th century, the nuclear industry thrived on standardization and regulation. However, today's workforce lacks the necessary experience, and existing regulations focus on large-scale plants.

To ensure a safe and publicly acceptable SMR-based nuclear energy solution, a new ecosystem with a supply chain, developers, operators, and maintenance providers has to be created, alongside a regulatory environment that is fit for purpose.

Firstly, the industry and regulators must collaborate to establish standards and enable technology benefits. Modularity and factory fabrication simplify the supply chain and construction, requiring new regulatory rules that support them. A new regulatory paradigm

***TO ENABLE SMRs TO OVERCOME DEVELOPMENT CHALLENGES AND FULFILL THEIR POTENTIAL IN THE ENERGY TRANSITION, CREATING THE RIGHT ENVIRONMENT IS CRUCIAL.***

is necessary to streamline certification and design modifications. Harmonized licensing frameworks can enhance nuclear power's appeal and ensure consistent risk management across borders, positively impacting policy makers and the public.

Secondly, the critical parts of the supply chain need to be identified and addressed. This may include assessing the technical risks in the supply chain, as well as availability. One key area that needs urgent solutions is the development of a skilled workforce. While it is relatively straightforward to put up factories, these need to be filled and operated with nuclear, mechanical, electrical, and civil engineers. Personnel with experience in nuclear power are currently lacking, and need to be established over time.

Finally, if large numbers of SMRs are to be built and operated in the coming decades, it requires state-of-the art O&M concepts, including Industry 4.0 solutions such as digital twins and predictive maintenance, assisted by AI and machine learning.

## INSIGHTS FOR THE EXECUTIVE

SMRs are likely to be increasingly important as a key part of the future energy mix. Executives would do well to include SMRs in their considerations about future energy supplies.

- **Keep track of nuclear developments:** Businesses need to stay up-to-date on developments in the nuclear industry and emerging technologies. This includes keeping track of regulatory changes, industry trends, and new innovations, as well as how this may affect their operations.
- **Reconsider nuclear as a part of the energy mix:** Companies should consider how the emergence of SMRs may involve new potential benefits from nuclear power in their energy strategies, including its low carbon footprint, reliability, scalability, and new use cases.
- **Build partnerships with nuclear industry leaders:** Businesses can benefit from building partnerships with nuclear industry leaders, which can provide access to knowledge, expertise, and technology. These partnerships can also help to build credibility and trust with stakeholders, including customers and investors.
- **Assess nuclear risks and opportunities:** Businesses should assess the potential risks involved with nuclear energy as a whole (e.g., regulatory, public approval, safety, and waste disposal) and the associated costs, as well as SMR-specific considerations such as not reaching full potential or immaturity of the technology itself. Conversely, executives should have a full overview of the opportunities presented by new nuclear technologies and the potential for cost savings.
- **Invest in nuclear education and workforce development:** Utilities and industry can play a critical role in promoting the development of the nuclear workforce. This includes supporting education and training programs for workers, as well as investing in research and development to advance the field. This can help to ensure a skilled workforce for the future and build a strong foundation for the nuclear industry.

**LARS THURMANN-MOE**

is a Partner in Arthur D. Little's Oslo office and a member of the Energy & Utilities Practice.

**BENEDIKT UNGER**

is a Principal in Arthur D. Little's London office and a member of the Energy & Utilities Practice.

**MICHAEL KRUSE**

is a Managing Partner in Arthur D. Little's Zurich office and global leader of the Energy & Utilities Practice.

**FREDRIK PEDERSEN**

is a Consultant in Arthur D. Little's Oslo office and a member of the Energy & Utilities Practice.

**ANDREAS DOBLOUG**

is a Consultant in Arthur D. Little's Oslo office and a member of the Energy & Utilities Practice.

**STIAN RØD**

is a Business Analyst in Arthur D. Little's Oslo office and a member of the Energy & Utilities Practice.

**HOW TO BUILD AND SCALE  
A MULTI-BILLION-DOLLAR**



# DIGITAL-FIRST CHALLENGER BRAND



## AUTHORS

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Barnik Chitran Maitra, Rohit Kapur, Amar Sinha, Pankaj Mann,  
Chirag Tibrewal, Tushar Arora

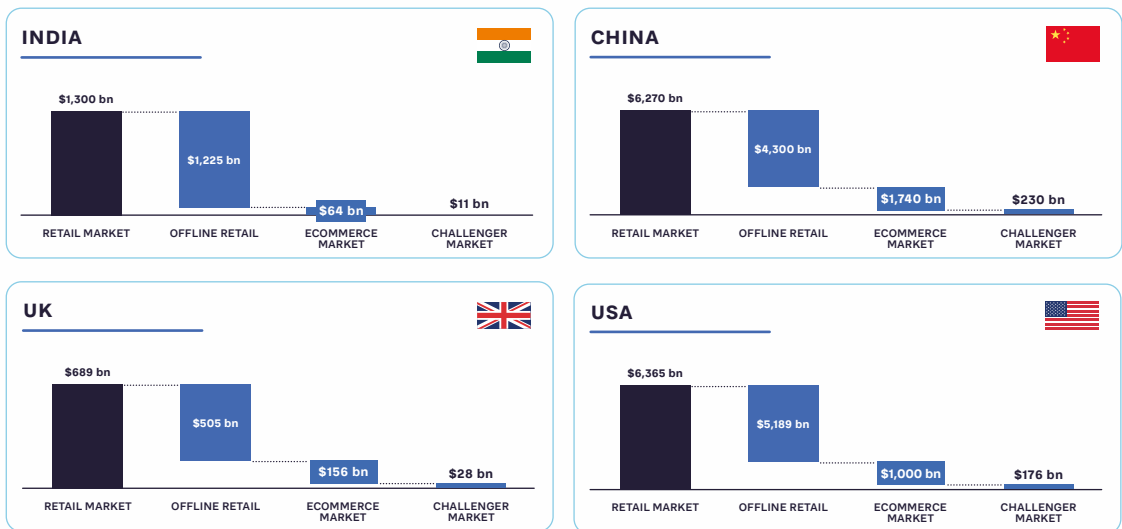
**Building a brand used to be a time- and resource-intensive process. The need to invest and align marketing, distribution, manufacturing, and sales outlets meant it was purely the domain of large players with deep pockets and lengthy experience.**

**These high barriers to entry limited brand creation to existing FMCG players that had manufacturing facilities, relationships with retailers, distribution channels, and large marketing budgets.**

However, the disruption caused by the internet, mobile, and digital, as well as the rise of new ancillary services (such as contract manufacturing and logistics), combined with changing consumer expectations, has turned this model on its head, creating a new category of digital-first challenger brands.

These new players can launch, market, distribute, and sell products in a more agile and cost-effective manner, tapping into a global market that is expected to reach over USD1.4 trillion by 2025, according to Euromonitor. Figures from Tracxn show that USD48bn has been invested since 2015 in over 4,157 funding rounds for challenger brands, many of which are seeing premium valuations. Chinese clothing company Shein was valued at USD64bn in March 2023, while razor brand Dollar Shave Club was bought by Unilever for USD1bn in 2016, just five years after it was founded.

However, digital brands face challenges due to market saturation, shrinking margins, and tighter access to funding. While they are cheap to start, they are harder to scale, with many finding it difficult to grow and reach long-term profitability. Given these issues, how can digital-first challenger brands thrive, and what can other brand owners learn from them?



**FIGURE 1: MARKET OPPORTUNITY FOR CHALLENGER BRANDS IN INDIA, THE US, CHINA, AND THE UK**

Figure 1 shows the market size of retail (USD bn), the online market, and the current opportunity captured by challenger brands. This highlights the size of the opportunity for challenger brands to grow and capture in retail.

## THE ACCELERATION OF BRAND CREATION

In the past, brands took years or even decades to become established. They were built on mastery of end-to-end processes controlled by the brand owner:

- R&D/product creation to meet customer needs
- Manufacturing within own facilities
- Marketing/branding to stimulate demand from consumers and retail partners
- Distribution/logistics delivering economies of scale
- Long-term retail partnerships
- Innovation to introduce new variants and build on the existing brand model

For example, Pepsi (founded 1965) solved issues around cold chain logistics with innovative packaging and formed partnerships with national bottlers to meet local needs and handle supply and distribution. Optimizing this model took decades and required a multi-million-dollar investment.

## THE RISE OF CHALLENGER BRANDS

Four key factors have disrupted the existing brand value chain and enabled digital challenger brands to develop:

- E-commerce, especially via smartphone and online marketplaces. Global online retail sales are expected to exceed USD7 trillion by 2025. This has removed the need for physical retail partnerships, replacing them with direct-to-consumer (D2C) channels.
- Digital marketing channels such as social media, digital advertising, reviews, influencers, and SEO. This has lowered the costs and time needed to create marketing campaigns, with better attribution enabling more agile, targeted spend.
- Changing consumer expectations, leading to an increasing desire for personalization, convenience, and novelty creating willingness to try new brands and products.
- The growth of ancillary services such as third-party logistics and contract manufacturing. Brands now don't have to own their own factories or build a supply chain, as partners such as Shopify (an e-commerce platform providing services for brands) and Shipstation (shipping and fulfillment) enable fast expansion into multiple markets/geographies.

## WHAT ARE THE COMPONENTS OF A SUCCESSFUL CHALLENGER BRAND?

Digital-first business models are based on six key pillars:



FIGURE 2: COMPONENTS OF A SUCCESSFUL CHALLENGER BRAND

## 1. USER EXPERIENCE

Brands create a seamless, fast, and positive digital experience for consumers, investing heavily in innovation such as the Metaverse and AI. For example, glasses brand Warby Parker offers a virtual try-on tool for users in conjunction with SnapChat, while e-grocery brands promise the convenience of 30-minute delivery. The user experience is continually improved through fast feedback loops based on consumer reviews and constant testing of new features.

## 2. DATA-DRIVEN INNOVATION

By using consumer data and insights, challenger brands find and target niches/white spaces, creating a close market fit. Showing the extent of this approach, Indian brand The Sleep Company has created a smart mattress that incorporates sensors to track sleep patterns. These insights are then used to drive product development.

## 3. PERSONALIZATION

Consumers increasingly want a personalized experience, not just a standard product. Digital channels and technology allow this to be delivered at scale. For example, Indian brand Fable Street provides workwear for women, tailored specifically for their shape and size using its proprietary Tailored Fit Algorithm.

## 4. AGILITY

Challenger brands are focused on acting on market and consumer data to quickly launch new products into new and existing markets. Shein produces smaller volumes of individual clothing products, but offers an enormous, fast-changing range, releasing 6,000 new items every day. Platform approaches support this agility. For example, Chinese smartphone company Xiaomi entered India via a partnership with e-commerce platform Flipkart and captured 11 percent of the market within two years.

## 5. ASSET-LIGHT BUSINESS MODELS

Through contract manufacturing, third-party logistics (3PL), and marketplaces (such as Amazon) for sales, challenger brands can operate extremely efficient, asset-light business models. For example, glasses brand Lenskart has outsourced manufacturing, enabling it to focus on product design, marketing, and customer engagement.

## 6. CREATE ECOSYSTEMS

By offering complementary products and services, challenger brands can cross-/upsell and create new revenue streams. Amazon began as an online bookstore and has expanded into smart home, music/entertainment, and cloud computing, for example. UK fitness clothing brand Gymshark now offers virtual training sessions, health supplements, and workout gear, creating a comprehensive fitness ecosystem.

# INNOVATION IN DIGITAL-FIRST BUSINESS MODELS – LESSONS FOR ALL BRANDS

Challenger brands have pioneered four main business models that can potentially be adopted by other companies.

## 1. SUBSCRIPTION

Offering products and services on a recurring basis allows brands to create predictable revenue streams and build long-term customer relationships. Customers value the combination of convenience and personalized experience brands deliver based on data analysis. Meal kit providers such as Blue Apron, Gousto, and Eat Fit all deliver pre-measured ingredients and recipes to customers, avoiding the need to shop and reducing food waste, for example. Subscription models also support other revenue streams, including website advertising, affiliate partnerships, and data sales.

## 2. HOUSE OF BRANDS

This approach minimizes overheads (such as customer service costs), creates supply-side synergies, and achieves scale through a single company offering a range of distinct brands targeting different consumer segments. Essentially, it is the digital equivalent of an FMCG brand company such as P&G or Unilever, with leaders including Thrasio in the US and India’s Mensa Brands, which achieved unicorn status in under a year. Success requires careful management and coordination to maintain each brand’s unique identity and positioning while achieving synergies. Figure 3 provides more details on Thrasio’s approach.

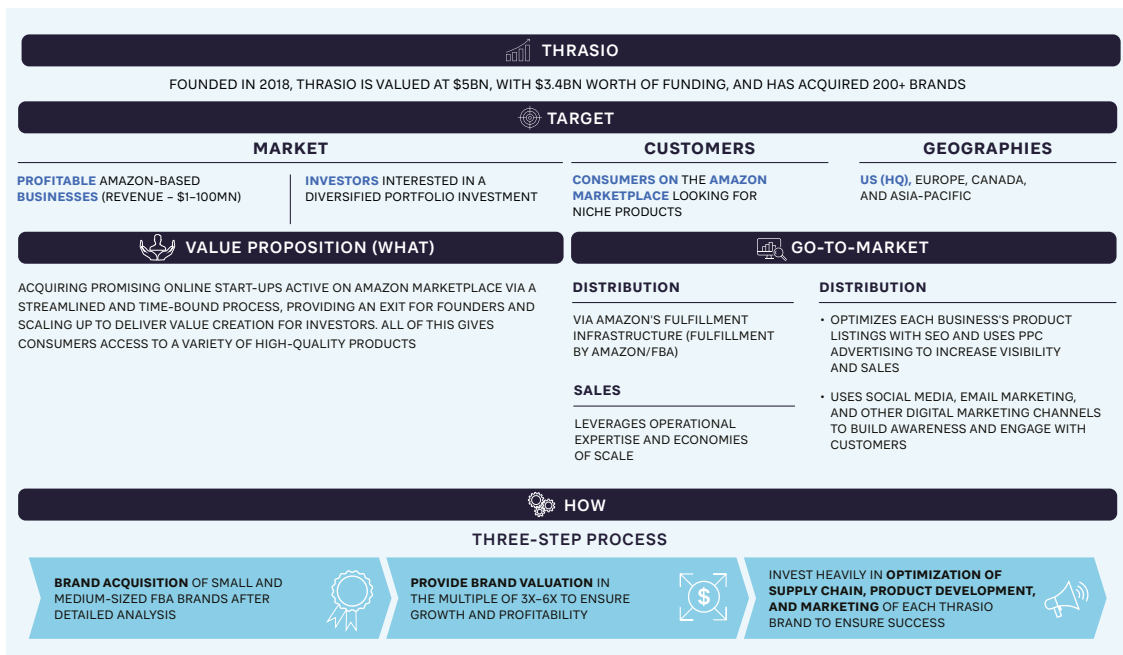


FIGURE 3: CASE STUDY ON THRASIO - US-BASED START-UP THAT ACQUIRES AND SCALES CHALLENGER BRANDS

### 3. HYPERLOCAL CHANNELS

Hyperlocal brands focus on serving a specific geographic area, typically within a few miles, to provide personalized and community-oriented products or services, from food and grocery to laundry. They deliver products ultra-quickly and use data to understand and meet the needs of their customers. Currently many of these brands (such as Deliveroo, Instamart, and TaskRabbit) are investing heavily to improve their efficiency and scale services to meet a market predicted to reach USD4,681.3 million by 2030 from USD1,344.7 million in 2021.

**HYPERLOCAL CHANNELS  
DELIVER PRODUCTS ULTRA-  
QUICKLY AND USE DATA TO  
UNDERSTAND AND MEET THE  
NEEDS OF THEIR CUSTOMERS.**

more regular visitors and diversifying revenues. For example, shoe company Allbirds has added a commission-free marketplace to its site, offering customers other sustainable fashion products from third-party sellers.

### 4. CURATED MARKETPLACE

To expand their reach and leverage their customer base, many challenger brands are creating their own curated marketplaces. These enable other brands to sell their products, attracting

## A FRAMEWORK FOR BUILDING AND SCALING A CHALLENGER BRAND

All start-ups currently face issues around securing funding, as described in *How to build a unicorn in the post-pandemic inflationary world* (Prism S1 2023). Challenger brands also need to overcome potential market saturation and meet fast-changing consumer requirements. Based on our experience and discussions with brands and investors, we recommend this framework to enable success:

### 1. BUILD TRUST AND A STRONG BRAND

Social media means feedback is instant and spreads virally. Building trust is crucial for brands, but challenging due to the crowded digital marketplace, lack of physical presence, and limited customer attention span. To create trust, challenger brands should focus on:

- Developing a clear brand identity that reflects their values and mission to differentiate from rivals
- Providing excellent customer service to build trust and loyalty
- Engaging with customers regularly through digital platforms to build community and address negative comments
- Leveraging influencers and partnerships to reach a wider audience and build credibility

For example, Indian beauty products brand Sugar builds strong trust with millennials by offering make-up products with colors suited to the Indian skin tone that can last a full day in the country's tropical climate.

"Being vocal about the company's story and purpose is crucial in building consumer trust and avoiding price competition," Founder, personal care D2C challenger brand

## **2. BE DATA DRIVEN WITHOUT COMPROMISING SECURITY AND DATA PRIVACY**

Consumers are increasingly concerned about how their personal data is being used, and want to do business with companies that take their privacy seriously. Brands should follow these data management practices:

- Collect only necessary data
- Use secure storage and robust data management practices
- Obtain explicit consent from consumers around data uses
- Provide transparency about data collection and usage
- Regularly review and update security measures

For example, UK clothing brand ASOS has published a clear data privacy policy and achieved ISO 27001 certification to reassure customers.

## **3. FOCUS ON PROFITABILITY TO OVERCOME THE MACROECONOMIC OUTLOOK**

Many D2C challenger brands benefited from the switch to digital channels and the closure of shops during the pandemic. The partial shift back to physical commerce has increased pressure around profitability. Investors are now more cautious about funding unprofitable growth, leading to brands pulling out of certain geographic areas. Digital-first brands therefore need to:

- Focus on profitability rather than simply user acquisition
- Create sustainable revenue streams, deliver operational efficiency, and differentiate their products/services
- Apply selective growth strategies, focusing on profitable markets/channels rather than rapid expansion at all costs

"Amazon advertising may not be cheap, but it's still more cost-effective than establishing physical stores or limiting ourselves to our own marketplace," Founder, consumer electronics challenger brand



## 4. STAY COMPETITIVE IN MARKETS WHERE BARRIERS TO ENTRY ARE LOW

Digital-first brands have lower profit margins than traditional retailers, with an average of 4.6 percent versus 11.6 percent, respectively. Increased price competition further hits margins, while low switching costs make it difficult to retain customers. Challenger brands therefore should:

- Create a unique value proposition
- Build a strong brand identity and messaging
- Leverage technology to improve the customer experience
- Collaborate to build new revenue streams
- Continuously innovate and evolve their offering

“Contract manufacturing and transitioning to organized retail allowed us to invest in brand building and expand into different regions,” Founder, personal care D2C challenger brand

## 5. FOCUS ON INNOVATION AND AGILITY

In a volatile world, brands must be flexible and respond to changes in customer preferences to remain competitive. Owning R&D of products

***IN A VOLATILE WORLD, BRANDS MUST BE FLEXIBLE AND RESPOND TO CHANGES IN CUSTOMER PREFERENCES TO REMAIN COMPETITIVE.***

gives the brand flexibility to innovate and develop unique products quickly. For example, mCaffeine, a coffee-based beauty products brand from India, owns its product R&D and launches innovative products regularly. Social media platforms frequently introduce new features or algorithms, requiring brands

to quickly adapt their digital marketing strategies, while consumer preferences can change overnight. Brands therefore need to:

- Be data driven and pivot quickly, such as by opening physical stores
- Own product R&D and embrace a culture of experimentation

“We prioritize using a launch-and-test approach over aiming for a perfect product from the start,” Founder, challenger coffee brand

## 6. ENSURE A CONSISTENT USER EXPERIENCE ACROSS ALL TOUCHPOINTS

As brands expand, inconsistency across touchpoints can lead to customer confusion and erode trust. This is a particular issue as companies rapidly add different channels, platforms, and markets while still being small in terms of size/employees. To mitigate this issue, challenger brands must:

- Establish a consistent brand identity across all touchpoints
- Align messaging and branding with target audiences
- Provide a consistent user experience across all touchpoints
- Train employees on brand values and ensure they can seamlessly convey them to customers

“As investors, we look for if the brand has ethos in its product development around uniqueness, scalability, and efficaciousness,”  
Managing Partner, Amicus Capital

## 7. ADOPT NEW TACTICS TO SCALE BEYOND TIER 1 MARKETS

Tier 1 cities provide a combination of savvy consumers, straightforward logistics, and digital infrastructure, making them the traditional starting point for challenger brands. However, they are now saturated and highly competitive, meaning brands need to scale beyond them and embrace smaller/emerging markets. This means overcoming challenges such as limited access to digital devices and internet connectivity, lack of trust in online transactions, and concerns around security. Brands therefore must:

- Launch targeted marketing campaigns to address the concerns and needs of consumers in tier 2/tier 3 cities
- Adapt business models and offerings to cater to local preferences and go omnichannel. For example, Harry’s Razors moved from being solely D2C to selling in Target (US) and Boots (UK), while FabIndia opened physical stores, especially in tier 2/3 cities
- Provide more flexible payment and delivery options, such as cash on delivery and pickup points
- Partner with local businesses and influencers to build credibility with consumers
- Invest in digital infrastructure and logistics to overcome operational challenges

“Most of the companies in our portfolio are witnessing massive growth from tier 2 cities, showcasing the need to focus on such underserved market segments,” Managing Partner, Amicus Capital

# INSIGHTS FOR THE EXECUTIVE

## FOR LARGER BRAND HOUSES

- **Create your own digital brands:** Create your own digital-first brand to launch new and innovative products, and aim to occupy white spaces in the landscape.
- **Partner with challenger brands:** Partner with challenger brands to create ecosystem synergies and benefits from respective competencies.
- **Invest through corporate venture capital (CVC):** Set up a CVC arm to invest in upcoming challenger brands.
- **Launch a sandbox for fostering innovation:** Identify and build in relevant categories that will benefit the parent brand.

## FOR INVESTORS

- **Set up dedicated expert teams for building challenger brands:** Develop novel themes for investment and provide guidance on business model innovations and opportunities.
- **Establish accelerator programs:** Set up accelerator programs to incubate early-stage start-ups.



**BARNIK CHITRAN MAITRA**

is a Managing Partner in Arthur D. Little's India & South Asia office and a member of the Strategy & Organization Practice.

**ROHIT KAPUR**

is a Head of PE & Transaction Advisory in Arthur D. Little's India office and a member of the Strategy & Organization Practice.

**AMAR SINHA**

is a Principal in Arthur D. Little's Dubai office and a member of the Telecommunications, Information Technology, Media & Electronics (TIME) Practice.

**PANKAJ MANN**

is a Consultant in Arthur D. Little's India office and a member of the Strategy & Organization Practice.

**CHIRAG TIBREWAL**

is a Consultant in Arthur D. Little's India office and a member of the Strategy & Organization Practice.

**TUSHAR ARORA**

is a Consultant in Arthur D. Little's India office and a member of the Strategy & Organization Practice.

# CHARTING THE COURSE NAVIGATING THE JOURNEY TO NATIONAL DIGITAL ECONOMY TRANSFORMATION



## AUTHORS

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Gergana Rangelova, Raymond Khoury, Andreas Buelow, Rajesh Duneja,  
Nawaf Almaskati, Kiseki Hirakawa

**At a country level, digitalization is seen as a driver of economic growth and skilled jobs creation. While the term “digital economy” is not new, recent developments mean policy makers must now rethink their digitalization agendas.**

Firstly, digitalization has become a critical factor in maintaining economic competitiveness, as it permeates all economic sectors, disrupting traditional production and exchanges and creating new growth opportunities. Digitalization is no longer optional – those that don't adopt it risk falling behind.

Secondly, data has become a strategic asset, with the insights unlocked by AI and machine learning creating sustained competitive advantage for businesses and individuals while enabling policy makers to make more informed, evidence-based decisions.

Thirdly, rapid technology evolution needs to be balanced with ethical considerations. For example, algorithmic bias and tech-driven job displacement are prompting discussions on the societal impact of technology in terms of fairness, equity, and inclusivity. Additionally, the use of data to train generative AI models has ignited concerns around IP ownership and the need to rethink national data protection policies.

Fourthly, the climate emergency is driving a need for radical action to meet net-zero commitments. Digitalization both enables decarbonization (such as through process optimization) and plays a key role in measuring, monitoring, and reporting on national progress towards net zero.

Finally, the digital economy is becoming an international, pan-government undertaking with geopolitical ramifications. Policy makers must find a balance between digital sovereignty over technology, IP ownership, and data protection and governance. International cooperation is necessary to harmonize digital regulations and facilitate cross-border data flows and digital trade agreements.



Based on insights from an exhaustive global benchmark of digital economy progress, this article explores how countries should react to these developments. They need to adopt a holistic approach to a nation’s digitalization that benefits sectors of interest and builds national differentiation and global competitiveness. They must understand the importance of each of the building blocks of digitalization and how they interrelate. Overall, nations need to adopt a collaborative and agile approach to maximize digitalization’s benefits and mitigate any potential risks.

## THE LINK BETWEEN THE DIGITAL ECONOMY AND ECONOMIC GROWTH

Digitalization delivers significant economic benefits through its positive impact on productivity, employment, and innovation. This is true across different country maturity levels – while digitalization can transform developing nations, it can also accelerate new services and innovation within developed countries, as economies such as Estonia, Singapore, and the US show.

Our global benchmark demonstrates that digitalized economies achieve higher productivity levels and faster economic growth than their peers, as shown in Figure 1<sup>1</sup>, which reveals a high correlation ( $R^2 = 0.47$ ) between digital transformation and GDP per capita levels. The International Labour Organization (ILO)<sup>2</sup> has estimated that the economic multiplier of digital investments is more than double that of other investments, delivering USD 3.79 versus USD 1.52 for each USD 1 spent.

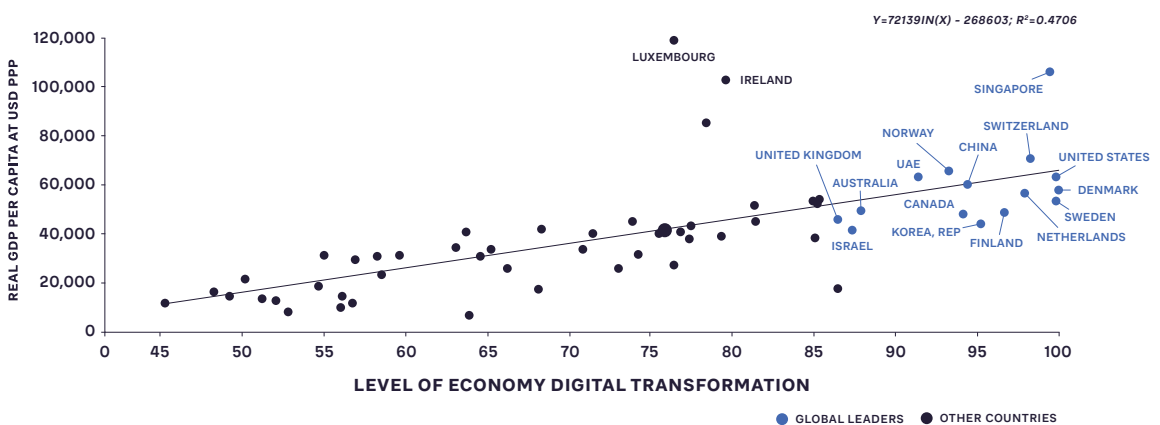


FIGURE 1: ECONOMIC PERFORMANCE VS. LEVEL OF ECONOMY DIGITAL TRANSFORMATION

1. Sources IMD, World Bank  
 2. Source: Changing demand for skills in digital economies and societies, ILO2

Governments have seen the importance of building digital economies for many years. However, it has risen in importance in support of advancing national development agendas due to the growing need for digitalization across the economy; an enormous increase in data volumes across all sectors, especially when coupled with AI; ethical considerations; the need to achieve net-zero targets; and the requirement to balance digital sovereignty and international cooperation.

## MEETING THE CHALLENGES OF CREATING A DIGITAL ECONOMY

Building a national digital economy is a large-scale program spanning many dimensions, involving many stakeholders, and lasting many years. Achieving ongoing success requires countries to focus on overcoming three key challenges, related to:

- **Regulations:** A balance is needed between the extremes of over-regulation and taking a laissez-faire approach. Governments need to adopt innovative regimes, such as sandboxes where experimentation can occur without regulatory constraints.
- **Funding:** Digital economy projects, particularly those of an enabling nature, require significant investment. Governments should consider alternative sources of funding, such as public-private partnerships (PPPs) and structuring monetization models for services. For example, Indian banks and telcos use government data-exchange systems to perform electronic verification checks on new customers, generating revenues for the platform itself.
- **Capabilities:** The skills required to digitalize, including programming, cloud computing, AI/data analytics, and cybersecurity capabilities, are in high demand across the globe. Governments must therefore invest in developing capabilities

**DIGITAL ECONOMY  
PROJECTS, PARTICULARLY  
THOSE OF AN ENABLING  
NATURE, REQUIRE  
SIGNIFICANT INVESTMENT.**

through education and training, while also attracting and maintaining such talent. Over the last 20 years, Singapore has embedded ICT in its educational curriculum, for example, helping nurture much-needed skills, while Estonia has launched a range

of measures, including a comprehensive digital talent attraction program that goes beyond dedicated visas.

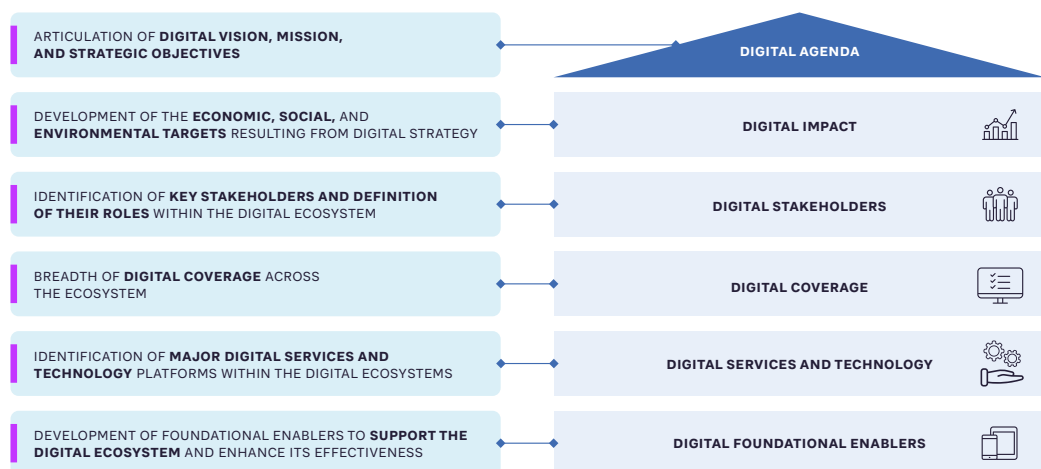
**Box 1: Enabling the data embassy concept in the Kingdom of Bahrain**

As data has become a strategic asset, concerns are arising around data privacy, security, and the ability of governments to protect their citizens’ data. Countries are increasingly demanding that sensitive data resides within their jurisdictions. While data sovereignty increases control and security, it can also reduce the benefits of using the cloud for cross-border exchanges and transactions.

Understanding the challenges of data protection, the Kingdom of Bahrain has taken an innovative approach to data sovereignty. The Kingdom passed its Decree on Providing Cloud Computing Services to Foreign Parties law in 2018. This embodies a clause on “data embassy,” which is a legal concept first introduced in a bilateral agreement between the governments of Estonia and Luxembourg in 2017. Data embassy allows customers and countries to store their information in data centers in the kingdom, while still being governed by their local domestic data protection laws – diplomatic immunity for data provisioning. The law positions the Kingdom uniquely, stimulating its economy by attracting investment and accelerating its progress to becoming a cloud computing hub.

## A NATIONAL DIGITAL ECONOMY FRAMEWORK – A ROADMAP TOWARDS DIGITALIZING ECONOMIC EXCHANGES AND OUTPUT

On the path to transforming their economies through digitalization, nations need to work holistically from vision to action. Analysis of our benchmark research, coupled with our experience, shows six critical elements to transforming an economy through digitalization, as set out in Figure 2.



**FIGURE 2: DIGITAL ECONOMY FRAMEWORK**

## 1. DIGITAL AGENDA

Start by defining an overall vision and strategic objectives. This vision acts as the North Star, steering all national efforts in one direction, while the objectives are measurable, achievable, and time-bound milestones on the journey. Digital Agenda setting is a critical element, as it allows policy makers to identify national priorities with the highest impact, allocate resources efficiently, and provide a common understanding and purpose to all relevant stakeholders, maximizing the chances of success. For example, Australia has created one of the world's most comprehensive and actionable digital economy strategies, built on the objective of creating a modern, leading digital economy by 2030<sup>3</sup>.

## 2. DIGITAL IMPACT

Digital impact is then derived from the vision, reflecting the desired outcomes and aspirations. Specifically, this entails defining the targets to be achieved:

- **Economic targets:** such as achieving higher economic growth, enhancing national productivity levels, and creating new jobs
- **Social targets:** achieving more inclusive economic growth with enhanced access to improved and more efficient public services (such as education, health, and pensions)
- **Environmental targets:** reducing emissions and waste, supporting climate change efforts, and empowering sustainable practices across economic sectors

Digital Impact allows countries to measure, evaluate, and communicate the effectiveness of their digitalization efforts, demonstrating value and enhancing accountability. South Korea is a strong example of comprehensive target setting, being one of the few countries that has put environmental issues at the heart of its New Deal digital program<sup>4</sup>.

## 3. DIGITAL STAKEHOLDERS

Identifying key stakeholders and defining their roles in the digital economy agenda are vital, particularly around the four areas of governance:

- Overarching strategy governance
- Sectorial digitalization
- Functional digitalization
- Enablement

3. <https://www.globalaustralia.gov.au/news-and-resources/news-items/australias-digital-economy-strategy-launched>

4. <https://www.iea.org/policies/11514-korean-new-deal-digital-new-deal-green-new-deal-and-stronger-safety-net>

Assigning clear roles and responsibilities guarantees commitment and accountability. It facilitates effective coordination, avoids duplication, and fosters synergies, such as around knowledge exchange and resource pooling. By identifying and involving relevant stakeholders, policy makers can ensure that sector-specific needs are addressed. In turn, stakeholders play a crucial role in shaping the vision, providing insights, and working together to achieve set objectives.

In Singapore, the Smart Nation and Digital Government Office (SNDGO) spearheads the implementation of digitalization initiatives and reports directly to the Prime Minister's Office. SNDGO has appointed dedicated digital officers in each ministry to act as a focal point for coordination. These officers ensure that initiatives are aligned with broader national digitalization objectives, while also acting as a point of contact for stakeholders within the ministry.

In addition to national stakeholders, policy makers need to engage internationally, fostering cooperation around areas such as harmonizing digital regulations and digital trade agreements.

#### 4. DIGITAL COVERAGE

Depending on Digital Impact objectives, nations need to define key priority sectors and create specific plans. These sector-specific strategies cascade overall national digital economy goals and align with sector priorities, outline the government's role, and set policies and incentives.

***IN SINGAPORE, THE SMART NATION AND DIGITAL GOVERNMENT OFFICE (SNDGO) SPEARHEADS THE IMPLEMENTATION OF DIGITALIZATION INITIATIVES AND REPORTS DIRECTLY TO THE PRIME MINISTER'S OFFICE.***

The Digital Coverage element is crucial as each sector has unique characteristics, requiring tailored sectorial digitalization policies that allow stakeholders to work together more effectively across the value chain. For example, the Danish Digital Health Strategy addressed specific healthcare focus areas, including

streamlining information flows between patients and healthcare professionals, while emphasizing security and privacy.

#### 5. DIGITAL SERVICES AND TECHNOLOGY

Programs need to develop key technology platforms and digital services that connect ecosystems and enable the seamless exchange of information, services, and goods. These Digital Public Goods (DPGs) and Digital Public Infrastructures (DPIs) include horizontal platforms such as digital ID, ePayment, eRegistries, eInvoicing, and data exchanges, as well as vertical sector-specific platforms such as national drug registration and inventory systems in the healthcare sector. For a more detailed look at DPGs and DPIs, refer to *Digital Public Goods – The benefits for citizens, governments, and businesses*, elsewhere in this issue of Prism.

Technology should be agile and interoperable, as well as meet the highest levels of data privacy and cybersecurity to instill trust and confidence, while creating a level playing field for businesses.

Identification and deployment of digital services and technologies is a critical element of the framework, as it empowers individuals and businesses to access information, connect with others, carry out transactions, etc., leading to increased productivity and convenience. The availability and adoption of interoperable horizontal and vertical digital services and technology platforms also underpin sector digitization.

Furthermore, the data gathered from digital services provisioning allows for evidence-based decision-making, provides insights for course correction or refinement of digital impact objectives, and fosters continuous improvement of sectorial policies and initiatives.

### **Box 2: Complementary digital platforms in Singapore**

Singapore has institutionalized a well-integrated system of horizontal and vertical platforms. Horizontal platforms include digital ID platform SingPass and ePayment system PayNow. Vertical platforms include the National Electronic Health Record, a patient health record management system, and Student Learning Space, a digital learning platform, along with others.

Showing the connections between them, SingPass serves as a gateway to the National Electronic Health Record system, facilitating secure access to patient healthcare data. It can also be used together with Student Learning Space to enable access to a wide range of education technology tools.

## **6. DIGITAL FOUNDATIONAL ENABLERS**

Foundational Enablers support the development of a digital ecosystem and enhance its effectiveness. They include developing a robust education and life-long learning system to guarantee the future readiness of human talent, ensuring the availability of financial capital, creating an enabling entrepreneurship and innovation ecosystem, and crafting a conducive legal and regulatory environment. Digital Foundational Enablers underpin the end-to-end digitalization journey and overcome key regulatory, funding, and capability challenges:

- Clear and adaptive regulations build trust and confidence, encouraging innovation and investment while safeguarding the interests of stakeholders.
- Focused education initiatives foster employability, inclusion, and entrepreneurship.
- Infrastructure investments facilitate deployment of digital technologies and development of innovative digital services that benefit citizens and businesses.

For example, New Zealand's latest digital strategy emphasizes upskilling and digital inclusion to empower people and organizations to pursue digitalization. It was driven by government research indicating that skills gaps were the main barriers to digital enablement among New Zealand businesses.

## INSIGHTS FOR THE EXECUTIVE

When embarking on national economy transformation through digitalization, policy makers need to view the process holistically, following seven best practices:

- **Make digitalization efforts central to a nation's strategic agenda:** The digital economy is not just about the ICT sector. More importantly, it is an enabler across the economy and society at large. Overall, digital economy strategies must consider this enablement role of technology, as well as align digitalization priorities with existing sectorial strategies and plans.
- **Focus on strong governance:** When implementing a national digital agenda, policy makers are often faced with resistance to change. They therefore must institutionalize governance structures that facilitate collaboration, communication, and recognition among stakeholders, as well as assign a lead entity with overarching authority to drive implementation.
- **Take a holistic, systematic view:** To be able to design effective policies, policy makers need to think holistically and understand the root cause of a problem and its ramifications for other initiatives. Digitalization efforts are unlikely to yield meaningful results without a plan that considers and effectively integrates interdependencies between the different elements of the digital ecosystem.
- **Involve the private sector:** As the key engine of economic growth, the private sector has a crucial role in the transformation journey. Policy makers need to keep an open dialogue with businesses, tapping into their innovation capabilities and involving them actively in both strategic planning and implementation.
- **Adopt an experimentation mind-set:** Digital success requires agility and readiness to experiment, taking measured risks and learning from failures – all behaviors that are not typical in a policy-making setting. Adopting an iterative approach with quick feedback loops is crucial for digital and non-digital solutions to be adapted to changing circumstances, as well as to ensure efforts are successfully focused.



- **Don't reinvent the wheel:** Learn from the experiences of others and adapt existing strategies and technologies to meet your specific needs. Building on successful programs from other countries and regions can accelerate and de-risk your own digitalization strategies, maximizing ROI.
- **Don't neglect long-term foundational enablers:** The benefits of foundational enablers such as ICT education take time to be realized. This may make taking "quick-win" measures more attractive. However, failing to invest in these enablers will undermine the pillars of the digital economy, making it unsustainable over time.



**GERGANA RANGELOVA**

is a Principal in Arthur D. Little's Dubai office and a member of the Telecommunications, Information Technology, Media, and Electronics (TIME) Practice.

**RAYMOND KHOURY**

is a Partner in Arthur D. Little's Beirut office and a member of the Technology & Innovation Management (TIM) Practice.

**ANDREAS BUELOW**

is a Partner in Arthur D. Little's Manama office and a member of the Financial Services (FS) Practice.

**RAJESH DUNEJA**

is a Partner in Arthur D. Little's Dubai office and a member of the Telecommunications, Information Technology, Media, and Electronics (TIME) Practice.

**NAWAF ALMASKATI**

is a Consultant in Arthur D. Little's Manama office and a member of the Strategy & Organization (S&O) Practice.

**KISEKI HIRAKAWA**

is a Business Analyst in Arthur D. Little's Dubai office and a member of the Strategy & Organization (S&O) Practice.

# DEMOCRATIZING TECH – HOW DIGITAL PUBLIC GOODS



# CAN BENEFIT CITIZENS, GOVERNMENTS, AND BUSINESS

## AUTHORS

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Barnik Chitran Maitra, Mayuresh Wagh, Fabian Sempf,  
Arjun Singh, Phil Webster

**Digitizing government services and processes is crucial to delivering greater efficiency and increased economic competitiveness, bridging equality gaps, and meeting the changing needs of citizens. Yet many government solutions failed the stress test of the pandemic, wasting scarce resources and adding to suffering.**

This is accelerating the adoption of Digital Public Goods (DPGs) – open technology solutions and platforms that transform the delivery of services in areas as diverse as financial services, healthcare, digital identity, education, and climate action. DPGs reduce potential dependence on large, global tech giants, empowering countries to adopt digital infrastructure solutions that they control themselves.

The OECD defines Digital Public Goods as “types of open-source software, AI models, and standards that countries can use to operationalize their Digital Public Infrastructure (DPI), such as payment and data exchange systems.”

Over 80 countries have launched DPG GovTech initiatives since 2014, and while the majority of these are low- to middle-income countries, such as India and Singapore, they also include Estonia, France (Data Gouv), the UK (GDS), and the US (with the health insurance exchanges created through the Affordable Care Act).

As governments take a bigger role in the lives of their citizens, DPGs help create a more open, participatory, trustworthy, and inclusive social ecosystem, while contributing to meeting the UN’s Sustainable Development Goals, particularly around poverty and healthcare.

DPGs also provide enormous transformative opportunities, opening up new markets for organizations as suppliers and participants. This article focuses on the opportunities that DPGs bring for both governments and businesses.

## THE CHANGING FACE OF DIGITAL PUBLIC GOODS

Digital public infrastructure (DPIs) and DPGs have existed since 2001, with Estonia a European pioneer in developing and managing distributed data exchanges between public and private organizations. Other countries have adopted DPGs to enable contactless payments, manage citizen health, provide digital identity, and improve the distribution of benefits. Digital public infrastructure has become as vital to the 21st century as railways, roads, and bridges were in the 19th and 20th centuries.

Demonstrating the scale of DPIs, in January 2023 India carried out 8 billion digital payment transactions worth USD200 billion through its Unified Payments Interface DPG, which involved 300 million people and 50 million merchants.

### THREE FACTORS HAVE ACCELERATED INTEREST IN DPGS

#### 1. Pandemic disruption found existing solutions wanting

Many countries struggled with outdated legacy tech during the pandemic, resulting in inefficiencies in the delivery of public services. However, countries such as India, which had the entire technology stack ready, with DPGs covering digital payments, e-Health systems, national identity, and e-Know Your Customer (KYC) (Figure 1), were able to outperform those that relied on closed legacy systems.



FIGURE 1: THE INDIAN TECH STACK

## 2. A desire for digital sovereignty

When choosing core technology, vendor lock-in is a key concern for many governments, particularly if suppliers are global, rather than locally based. As solutions hold increasing volumes of sensitive data about citizens, data sovereignty is also moving to the top of government requirements. Countries need to know where information is stored, who has access to it, and how it is controlled. As DPGs are open, they can be adopted and adapted across countries – for example, Estonia’s X-Road data exchange platform has also been rolled out in Japan, Finland, Iceland, and the Faroe Islands.

## 3. Greater funding and international focus

The 2022 UN Future of Digital Co-operation saw greater focus and funding for DPGs from a wide range of NGOs. Major donors, including the Bill & Melinda Gates Foundation, UNICEF Ventures, USAID, and the Omidyar Network, committed around USD300 million in total to DPG/DPI initiatives during the 77th United Nations General Assembly in 2022.

### **Box 1: Digital Infrastructure for Verifiable Open Credentialing (DIVOC)**

During the COVID-19 pandemic, India wanted to protect its over 1.5 billion citizens through the fast rollout of mass vaccination programs. While last-mile logistics were in place, India needed a digital platform to manage vaccine distribution, and to issue secure and tamper-proof digital vaccination certificates at scale.

To overcome this challenge, it developed the Digital Infrastructure for Verifiable Open Credentialing (DIVOC). DIVOC is an open-source digital platform that issues WHO-compliant digital vaccine certificates at scale through phone, web, and even WhatsApp. It integrates with private healthcare wallets and is interoperable with international travel formats.

# UNDERSTANDING THE PUBLIC AND PRIVATE SECTOR BENEFITS OF DPGS

## BENEFITS FOR CITIZENS AND GOVERNMENTS

DPGs either replace proprietary technology solutions or digitize previously paper-based processes. For nations and their citizens, they:

- Improve the delivery of public services
- Enable digital inclusion and support the achievement of Sustainable Development Goals, even for those at the bottom of the pyramid
- Enhance transparency and accountability
- Increase efficiency by making processes faster, digital, and secure, as well as cutting fraud and eliminating paperwork
- Improve cybersecurity and data protection

The public benefits of DPGs are clear. For example, Estonia's digital signature-based e-ID system has resulted in savings of approximately 2 percent of GDP for the government. The IMF estimates that India saved USD34 billion (1.1 percent of GDP) between 2013 and March 2021 by reducing welfare payment fraud through its Aadhaar payment DPG.

### **Box 2: Improving health insurance coverage with a customer-first approach in the US**

Introduced in 2010, the Affordable Care Act (ACA), better known as Obamacare, aimed to provide affordable health insurance coverage for all Americans. One of its underlying principles is the creation of Healthcare Exchanges (marketplaces) at a state and federal level. These DPGs enable individuals to compare and buy insurance plans from ACA-compliant private players, as well as receive income-based government subsidies.

As well as the federal government-run HealthCare.gov exchange, which serves citizens in 33 states, 18 states run their own platforms. Overall, 16 million individuals have enrolled on exchanges, leading to a decrease in the annual uninsured rate from 17 percent in 2013 to 8 percent in 2022.



## BENEFITS FOR BUSINESSES

The benefits for the private sector can be less well-understood. DPGs help to drive innovation, increase efficiency, and improve customer satisfaction in four key ways:

### 1. By providing a level playing field for start-ups and SMEs

By making their platforms open and accessible to all, DPGs open up opportunities for all businesses. For example, India's Unified Payment Interface (UPI) enables everyone to make and accept digital financial transactions. This means even street vendors can accept digital transactions cost-effectively, without requiring sophisticated, expensive point-of-sale solutions.

### 2. By fostering innovation and entrepreneurship

Companies can leverage the technology stack/open-source framework created by DPGs to build their own innovative products on top more quickly and efficiently. For example, Walmart-owned PhonePe, Google, Amazon, WhatsApp, and Paytm are building platforms based on the Indian UPI framework.

### 3. By reducing operational costs and required investment

As DPGs are freely available open-source software and platforms, businesses can easily incorporate them into their products or services. This reduces technology costs, allowing businesses to focus

investment in other areas. Indian banks and telcos use DPGs such as Aadhaar-based digital ID and consent-dependent data exchange systems to perform new customer verification checks electronically. This has brought down the cost of verification from USD 6–9 per person to just 40 cents.

**COMPANIES CAN LEVERAGE THE TECHNOLOGY STACK/ OPEN-SOURCE FRAMEWORK CREATED BY DPGS TO BUILD THEIR OWN INNOVATIVE PRODUCTS ON TOP MORE QUICKLY AND EFFICIENTLY.**

### 4. By providing a more secure and trustworthy environment

DPGs provide secure digital infrastructure for businesses, enabling them to securely store and manage sensitive data, as well as comply with data privacy regulations and standards such as GDPR and ISO 27001. For example, Singapore's OpenAttestation, a DPG for document verification using blockchain, ensures the authenticity and integrity of digital documents, making legal compliance easier for businesses, particularly around trade finance.

# THE CHALLENGES TO DELIVERING A SUCCESSFUL DPG

Given their scale, potential complexity, and use of personal information, creating a DPG/DPI is not straightforward, as Figure 2 explains. Five main challenges must be overcome:

## FROM IDEA TO SCALE, SUCCESS STORY?

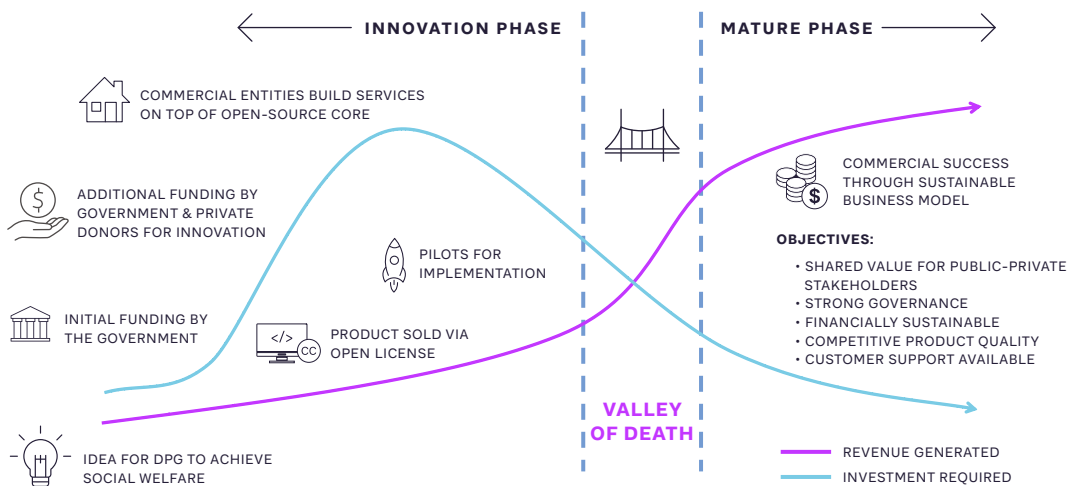


FIGURE 2: THE DPG JOURNEY

### 1. FINANCE

Developing and maintaining a DPG requires large upfront investment. Owners have to finance development and build a sustainable business model, independent of government budgetary support. Changes in government priorities, especially in the early phases of projects, can also have a negative effect on DPG development.

### 2. PRIVACY AND SECURITY

With the increasing use of technology to collect, store, and share personal data, governments must ensure that appropriate data privacy and security measures are in place. DPIs, especially national identity databases (such as e-ID in Estonia), contain sensitive biometric information that needs extra layers of security protection. APIs linked to this data must be carefully designed to prevent the misuse of sensitive personal information.

### 3. DIGITAL INCLUSION

DPGs require citizens to have a combination of internet access, digital literacy, and digital devices. Governments need to ensure basic internet infrastructure is in place across their entire population, as well as ensure that DPGs can be accessed at slow internet speeds

and without requiring any additional devices. Rwanda has rolled out infrastructure to provide 96 percent 4G coverage, while Tanzania has adapted digital health services so they work on its low-bandwidth 2G/3G networks.

#### 4. GOVERNANCE

DPGs are non-rivalrous resources managed by sovereign entities, making strong, transparent governance vital. Governments need to ensure that platforms are equitable, secure, effective, usable, and cost-effective. Owners need to balance the competing needs of different stakeholders with their finite capacity and resources to maximize benefits for all.

#### 5. TECHNOLOGY

DPGs and DPIs are major technology projects. Even if they are based on existing open-source DPGs from other countries, these will need to be adapted and customized to the specific needs of the local population. Managing this scale and complexity is a major challenge that needs to be addressed through investment in resources and skills.

#### **Box 3: Ayushman Bharat Digital Mission (ABDM)**

Launched in September 2021, India's Ayushman Bharat Digital Mission (ABDM) aims to foster a digital health ecosystem in the country, leveraging open, interoperable, standards-based digital systems, and ensuring security, confidentiality, and privacy of health-related personal information.

It covers three areas, enabling:

- Interoperable health services via a Unified Health Interface (UHI), allowing consumers to access any participating healthcare provider
- Interoperable health data via Health Information Exchanges (such as personal health records, public health data, and anonymized datasets for machine learning)
- Interoperable health claims via Health Claim Exchanges, standardizing information interchange between payers and providers

Over the past 18 months, the ABDM program has significantly scaled up, creating over 400 million Health IDs and registering 200,000+ health facilities and 180,000+ healthcare professionals.

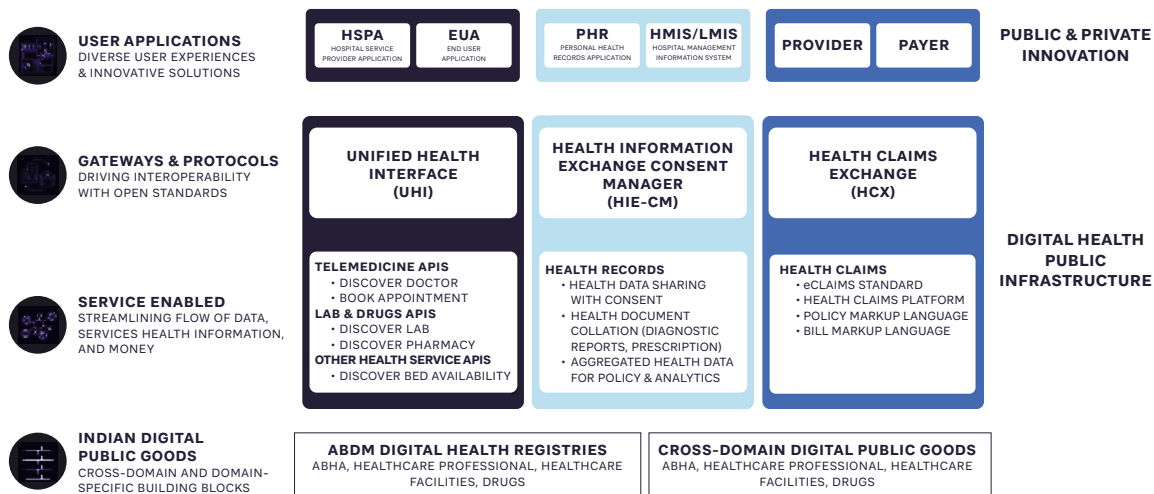


FIGURE 3: AYUSHMAN BHARAT DIGITAL MISSION STRUCTURE

## ACHIEVING SUCCESS FOR THE PUBLIC AND PRIVATE SECTOR

### GOVERNMENT

Based on global experience, governments need to focus on four key dimensions while building DPGs:

#### 1. Build it as an ecosystem

While governments fund the initial development of DPGs, they often lack the incentives to scale solutions. To overcome this, DPGs require a self-sustaining business model, delivered through the creation of an open marketplace or ecosystem. This provides the opportunity to drive scale and revenues. The India Stack (Figure 1) typifies this approach, working with private players to build a sustainable, financially viable solution.

#### 2. Scalable, interoperable infrastructure with minimal blocks

DPGs should be built using open-source and modular technologies, facilitating the exchange of information between the public and private sector, and be adaptable across countries. South Africa’s District Health Information Software 2 (DHIS2) is a prime example of this trend. Overseen by Norway’s University of Oslo, it is presently the largest global platform for health management information and has been adopted in 73 countries, accounting for 30 percent of the global population.

#### 3. Partner with private players

Private sector players can bring new ideas and technologies that can lead to better functionality and scaling of DPG initiatives. For example, the government of Singapore has partnered with players such as IBM and Microsoft to develop and implement blockchain-based solutions for document verification and supply chain

management. Private players helped design and implement the technology, while the government provided the necessary regulatory framework and support.

#### **4. Leverage global cooperation**

Digital public goods are available to be freely adopted and adapted by governments across the world. Instead of reinventing the wheel, governments should try to leverage existing DPG initiatives, enabling savings on resources and faster implementation. The mass rollout of the DIVOC system beyond India to Sri Lanka, Jamaica, Indonesia, and the Philippines demonstrates the strength of this approach.

## **PRIVATE SECTOR**

The rise of DPGs provides private sector organizations with opportunities to innovate and create new use cases in four key areas:

### **1. Enable new business opportunities**

Private players can grow their business and generate additional revenue streams, whatever their size. DPG initiatives often target underserved populations, providing an opportunity for the private sector to tap into new markets. For example, India's Open Network for Digital Commerce (ONDC) aims to create an interoperable network for digital commerce and includes participants such as Amazon and Flipkart (owned by Walmart).

***INSTEAD OF REINVENTING THE WHEEL, GOVERNMENTS SHOULD TRY TO LEVERAGE EXISTING DPG INITIATIVES, ENABLING SAVINGS ON RESOURCES AND FASTER IMPLEMENTATION.***

### **2. Leverage DPGs to improve customer choice and build trust**

DPGs transform industries and provide access to greater consumer choice, while creating deeper trust. Obamacare's Healthcare Exchanges have allowed private sector insurers

to offer competitive healthcare plans, while consumers have been empowered to make better buying decisions.

### **3. Improve business efficiency and reduce costs**

DPGs enable private sector players to improve business efficiency by streamlining operations and automating processes. For example, Estonia's X-Road allows for secure data exchange between government agencies and with private sector businesses. Businesses can submit regulatory documents online, reducing paperwork, improving transparency, and decreasing corruption risks.

### **4. Innovate**

Companies can build applications on top of DPIs/DPGs, which enables them to innovate cost-effectively. Google developed its Google Pay app running on India's UPI DPI, differentiating it by adding its own innovative features, such as rewarding customers for using the app to make payments. This has enabled Google to acquire new customers and create revenues from channels such as advertising.

## **INSIGHTS FOR THE EXECUTIVE**

### **FOR GOVERNMENTS**

- Understand that DPGs deliver benefits for all countries – they are not solely the province of low-/middle-income countries.
- Be ambitious and look at where DPGs and DPIs can transform efficiency, relationships with citizens, and overall effectiveness and create a bold vision for national adoption.
- Understand currently available DPGs and see if they can be adapted to particular needs.
- Create industry-wide specific roadmaps for DPG and DPI rollouts, and explore innovative institutional mechanisms to drive scale-up and adoption.

### **FOR CEOs**

- Build knowledge of current and planned DPGs in existing and potential markets – how can they create new opportunities?
- Understand and plan for any competitive threats from the adoption of DPGs.
- Partner with governments/DPGs where possible to maximize ecosystem benefits.
- Innovate around DPG ecosystems and use them to build new products, solutions, and revenues.

**BARNIK CHITRAN MAITRA**

is a Managing Partner in Arthur D. Little's India & South Asia office and a member of the Strategy & Organization Practice.

**MAYURESH WAGH**

is a Consultant in Arthur D. Little's Mumbai office and a member of the Strategy & Organization Practice.

**FABIAN SEMPF**

is a Principal in Arthur D. Little's Delhi office and a member of the Automotive Practice.

**ARJUN SINGH**

is a Partner in Arthur D. Little's Dubai office and a member of the Financial Services Practice.

**PHIL WEBSTER**

is a Principal in Arthur D. Little's London office and a member of the Technology & Innovation Management (TIM) Practice.

# **HYDROGEN**

## **THE ELECTROSHOCK TO THE ENERGY TRANSITION**





## AUTHORS

Florence Carlot, Oliver Golly, Carlo Stella, Benedikt Unger,  
Thomas Oosterlinck

**While much of the focus on achieving net zero has been on green electricity, momentum is growing behind hydrogen within the energy transition, with the IEA predicting a four-fold increase in demand between now and 2040.**

Governments are increasingly supporting its adoption through a range of incentives, such as those within the US Inflation Reduction Act (IRA), EU funding programs, India's Hydrogen Mission, and Australia's Hydrogen Headstart program. Together

with electrification, hydrogen will help accelerate transformative decarbonization, especially in sectors in which emissions are otherwise hard to abate.

***TOGETHER WITH ELECTRIFICATION, HYDROGEN WILL HELP ACCELERATE TRANSFORMATIVE DECARBONIZATION, ESPECIALLY IN SECTORS IN WHICH EMISSIONS ARE OTHERWISE HARD TO ABATE.***

However, uncertainties still exist around hydrogen's growth and relevant business models, including questions around supply, demand, transportation, and regulation. For this reason, players in the energy ecosystem, whether suppliers, customers, or investors, all need to take a fresh look at their strategies and investment plans. This article explores the opportunities for hydrogen in the energy sector and outlines the critical

factors that companies across the ecosystem must consider to successfully integrate it into their strategies.

# THE ROLE OF HYDROGEN ACROSS THE ENERGY VALUE CHAIN

Hydrogen has the potential to impact the upstream, midstream, and downstream energy value chains.

## UPSTREAM

Adding Carbon Capture Utilization and Storage (CCUS) technology to fossil fuel-based hydrogen production or electrolysis using renewable electricity significantly reduce greenhouse gas (GHG) emissions. However, viability relies on the availability of affordable renewable electricity – for example, electrolysis-based hydrogen production typically requires the availability of at least 4,000-5,000 hours of electricity per year.

## MIDSTREAM

Hydrogen can be transported via pipelines, trucks, or ships. However, existing pipelines and storage facilities are designed for natural gas and will require large-scale transformation to transport and store

hydrogen. Hydrogen transportation through trucks or ships (as liquid hydrogen, ammonia<sup>1</sup>, or a liquid organic hydrogen carrier [LOHC]) will also require new or repurposed infrastructure.

Large-scale storage of hydrogen has the potential to dramatically increase system resilience, as it can be used to store energy generated from renewable sources, which can then be used during peak demand periods. Midstream impacts will depend on the cost and availability of infrastructure and the regulatory framework for hydrogen transportation. Many gas transmission system operators (TSOs) are already analyzing the required

changes, running pilots, designing projects, attracting investments, and starting preparatory construction works.

changes, running pilots, designing projects, attracting investments, and starting preparatory construction works.

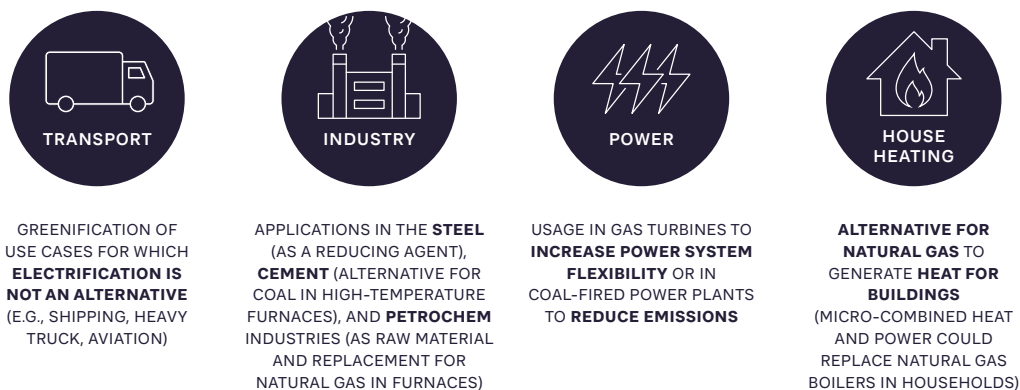
## DOWNSTREAM

Hydrogen can be used for transportation, industrial processes (such as steelmaking, refining, and chemical production), power generation, and residential heating, as illustrated in Figure 1. Another viable use is as a source for e-fuel<sup>2</sup> when coupled with CCUS technologies, an example being the Haru Oni pilot plant in Chile. Adoption and the impact on the downstream value chain will depend on hydrogen availability, as well as the cost and efficiency of hydrogen-based technologies such as vehicles and heating systems.

**ADDING CARBON CAPTURE UTILIZATION AND STORAGE (CCUS) TECHNOLOGY TO FOSSIL FUEL-BASED HYDROGEN PRODUCTION OR ELECTROLYSIS USING RENEWABLE ELECTRICITY SIGNIFICANTLY REDUCE GREENHOUSE GAS (GHG) EMISSIONS.**

1. Ammonia can be used as a hydrogen carrier to transport it more effectively and safely over long distances due to its more favorable characteristics, having higher energy density and being less flammable.

2. E-fuels are fuels produced from renewable sources such as solar or wind power.



PROJECT EXAMPLES

THE CORADIA ILINT™, THE WORLD'S FIRST PASSENGER TRAIN POWERED BY A HYDROGEN FUEL CELL, PRODUCING ELECTRICAL POWER FOR TRACTION



THYSSENKRUPP SWITCHING ITS STEEL PRODUCTION TO DIRECT REDUCTION BY 2021 WITH HYDROGEN SUPPLY FROM RWE



CONSORTIUM DEVELOPING A POWER-TO-HYDROGEN-TO-POWER PROJECT



PARTNERSHIP DEVELOPING FIRST UK PUBLIC DEMONSTRATION OF A HOME FUELED ENTIRELY BY HYDROGEN



FIGURE 1: HYDROGEN APPLICATION IN VARIOUS SECTORS

As detailed in Figure 2, a range of opportunities will emerge across the value chain, particularly around green energy supply and hydrogen production. Businesses should explore where these fit with their overall strategy, capabilities, and risk appetite, and move quickly to secure the right energy sources and form partnerships to access hydrogen volumes at good prices.

ECONOMIC SET-UP OF HYDROGEN ECONOMY IN 2050 IN EUROPE



FIGURE 2: VALUE GENERATION ALONG THE H2 VALUE CHAIN IN EUROPE BY 2050

## RISKS TO THE DEVELOPMENT OF THE HYDROGEN ECONOMY

While the hydrogen value chain provides major opportunities for incumbents and new players, it also faces multiple risks and uncertainties, including:

- **Cost/competitiveness:** The cost of producing, transporting, and storing hydrogen is currently higher than that for conventional fossil fuels, due to the immature technologies across the value chain and expensive long-haul transport. Although costs are expected to decrease significantly in the long term, companies investing now in hydrogen infrastructure and technology may not generate short-term profits. Even if costs fall, producing hydrogen may still be more expensive than alternatives such as renewable power from an upstream perspective. However, due to its ability as a stored energy carrier, and its usage in otherwise difficult-to-decarbonize sectors, many expect it to be ultimately competitive with alternatives.
- **Lack of infrastructure:** Available infrastructure to support the production, transportation, and storage of hydrogen is limited,

**ACCORDING TO THE EUROPEAN HYDROGEN BACKBONE, PIPELINE OPEX COULD AMOUNT TO USD 3.6 BILLION PER YEAR IN EUROPE ALONE.**

preventing scaling of supply and demand. For example, fuel cell vehicle uptake will go hand-in-hand with the ramp-up of hydrogen refueling stations. The underlying challenge is that infrastructure

is expensive to operate and maintain safely. According to the European Hydrogen Backbone, pipeline OPEX could amount to USD 3.6 billion per year in Europe alone. To overcome this, alongside direct financial support, many economies (such as the United States, Canada, Australia, and Korea) are establishing regional hydrogen hubs. Establishing hydrogen production close to end users minimizes the cost of infrastructure construction and operation, jumpstarting adoption.

- **Market design/regulatory development:** The regulatory framework for hydrogen is still evolving, and there is uncertainty around how governments will incentivize or regulate hydrogen technology. For example, the role TSOs can play in the upstream part of the value chain, or which requirements will be set regarding the carbon intensity of hydrogen to classify it as low emission, are still unclear. Potential new internationally agreed emissions accounting frameworks could also create short-term uncertainty. This presents an opportunity for countries/regions to differentiate themselves and accelerate development by rapidly creating favorable regulatory environments for investment.

- **Technology evolution/uncertainty:** The technology for producing and storing hydrogen is still developing, and how to best optimize processes for maximum efficiency and cost-effectiveness is currently unclear. Scalability is lacking around many technologies, such as ammonia cracking (to reconvert ammonia to hydrogen) or liquefaction/re-gasification. These are therefore likely to see significant future improvements in efficiency.
- **Market demand:** While interest in hydrogen as a fuel and energy storage medium is increasing, how quickly and widely it will be adopted is still unclear. However, awareness of hydrogen as an alternate energy solution is growing, as shown by the range of strategies and initiatives being put in place across leading economies.
- **Competition:** A growing number of companies are entering the hydrogen market, including traditional energy players, grid companies, automotive manufacturers, industrial gas providers, and technology and chemical companies. This could lead to increased competition and potential market saturation.

***EMBRACING HYDROGEN WILL ENABLE BUSINESSES TO ALIGN WITH SUSTAINABILITY GOALS, ATTRACT CUSTOMERS, DIFFERENTIATE THEIR OFFERINGS, FOSTER COLLABORATIONS, AND DRIVE BUSINESS MODEL INNOVATION.***

- **Geopolitical risk:** If the majority of hydrogen is supplied by Middle Eastern and African states (such as Qatar, Saudi Arabia, and Morocco), regions such as Europe will simply trade dependency on Russian gas for dependency on hydrogen from other countries, which could create risk.

These factors complicate the decision-making process around which investments to make and when and where to make them for all actors within the ecosystem, from suppliers to users.

## THE NECESSITY AND ADDED VALUE OF INNOVATION

Innovation along the hydrogen value chain will be essential to overcome technical and economic challenges, scale up hydrogen production and utilization, reduce costs, and drive the transition to a sustainable and low-carbon energy future.

As well as advances within generation, storage, and transport innovation, hydrogen's versatility will enable multiple sectors to innovate, create synergies, and optimize energy systems. For instance, innovations in hydrogen utilization technologies, such as fuel cells and hydrogen-powered vehicles, will drive the adoption of hydrogen as an alternative energy source.

Embracing hydrogen will enable businesses to align with sustainability goals, attract customers, differentiate their offerings, foster collaborations, and drive business model innovation. By generating hydrogen without emitting carbon, companies will earn carbon credits, which can be sold or used to offset emissions across their wider operations, providing a further financial incentive for hydrogen investment. By adhering to certification requirements (not limited to carbon footprint, but also including purity and safety), businesses can build trust and credibility, opening up opportunities for new partnerships, market access, and premium pricing.

## SUCCESSFULLY PLAYING IN THE HYDROGEN ECONOMY

Given the fast-moving and dynamic nature of the hydrogen economy, organizations and investors will need to be extremely agile to build a competitive position, which will require them to transform internally.

### DEFINING NEW BUSINESS MODELS

Organizations need to understand and plan their positioning in the hydrogen economy. For example, hydrogen players in Japan and Korea might need to invest in electrolyzer capacity and hydrogen production overseas in Australia or Malaysia, and create a supply chain back to their country. This international business model is likely to impact the capabilities and organizational structures they develop and the partnerships they form.

### DEVELOPING A CUSTOMER-CENTRIC MIND-SET

Greater competitiveness and uncertainty require previously dominant players in the gas industry, such as TSOs, to transform their mind-set and operations. They are unlikely to be the sole player in hydrogen markets, so they need to move away from monopolistic thinking and focus on becoming agile, fast-moving, and customer centric. They must start by understanding client requirements and using this to build stronger relationships.

### CREATING ECOSYSTEM PARTNERSHIPS

Exploiting new opportunities will require collaboration with partners all around the globe, for example, with companies using solar power to create hydrogen in regions such as the Middle East and Australia, as well as forming joint venture agreements with worldwide customers to guarantee large-scale, stable demand. Partnerships between the public and private sector will drive change. One example is the establishment of Thailand Hydrogen Group, initiated by oil and gas company PTT, which aims to engage public and private sector players to promote the development and adoption of hydrogen in Thailand.

## DEVELOPING NEW ORGANIZATIONAL STRUCTURES

To deal with the broad uncertainties around feasibility and investment choices, companies need to create new organizational structures that are faster-moving and more adaptable to changing conditions. This should include creating teams with skills in business development, engineering (especially technical expertise in the hydrogen space), and finance, as well as effective communication to create awareness, build stakeholder support, and lobby for the right regulatory frameworks and support mechanisms.

## BUILDING INFORMED AND DIVERSIFIED INVESTMENT STRATEGIES

To reduce risks in a rapidly evolving and complex market, companies should diversify investments across hydrogen technologies and market segments, such as by allocating resources to both fuel cell technology and hydrogen production technology. Alternatively, they could consider projects outside (but related to) hydrogen, such as green ammonia and methanol, especially as hydrogen is part of a broader ecosystem. Investments should also be divided evenly between hydrogen and other less volatile energy sectors to spread financial risks, guided by the company's risk appetite.

In this challenging landscape, making informed decisions is crucial. Scenario planning serves as a valuable tool to assess the resilience of potential strategies across different scenarios. It aids in identifying “no regret” decisions that can be implemented immediately, while also establishing monitoring mechanisms for triggers that may impact other investment choices. Sustainability scenario planning is described in more detail in *Navigating the sustainability journey* (Prism S1 2023).

## BUILDING A LONG-TERM PERSPECTIVE

In the evolving hydrogen ecosystem, roles within the value chain remain fluid, particularly due to evolving regulatory policies and incentives. Players need to take a long-term perspective, assessing the potential growth and scalability of hydrogen technologies and the market before making investment decisions. For example, producers and transporters need to evaluate the potential hydrogen volumes per sector in their respective areas and identify attractive business models while considering their specific circumstances.



By actively collaborating with industry stakeholders, such as technology providers, energy companies, hydrogen users (off-takers), and government agencies, producers, transporters, and investors can gain valuable insights into market developments. Building long-term partnerships and working together allows for cross-leveraging of capabilities, reduces inherent uncertainty, and mitigates operational and demand risks.

Assessing policy evolutions and regulatory frameworks on a global scale is essential to understand their potential impact on investment decisions. For example, subsidies and tax incentives can create favorable investment environments in specific areas of the value chain. Initiatives to focus on include the US Inflation Reduction Act, Hydrogen Headstart in Australia, the EU Hydrogen Strategy, the Fit-for-55 package, the Innovation Fund, and the European Green Deal.

## INSIGHTS FOR THE EXECUTIVE

Hydrogen has a key role to play in successfully delivering a low carbon economy. However, its ecosystem is still developing, meaning opportunities are not yet clear for players such as producers, energy companies, transporters, distributors, retailers, end users, and investors. To understand how to play, organizations should focus on:

- **Building internal understanding:** Investigate market opportunities, potential impacts on operations, and the optimal timing around entering the hydrogen market. Companies should evaluate hydrogen volumes, market prospects, and required business models, and understand customer needs. Implementing technology and market monitoring, along with scenario planning, ensures strategic preparedness.
- **Developing the right organization and capabilities:** For existing energy players, success in the hydrogen economy will require organizational transformation. This could include developing a more commercial, customer-focused mind-set, with new teams hunting for and realizing opportunities in the hydrogen value chain.
- **Working closely with regulators:** Across the globe, from the EU to the United States and Asia, national and regional governments are actively involved in setting the ground rules for the hydrogen economy. Be clear on the opportunities that are available (such as through subsidies) and the regulatory decisions that could constrain strategies or operations.
- **Capitalizing on value pockets:** Go beyond the hype around the demand side to understand where opportunities exist (such as in e-fuels, direct combustion, or heavy transport) and focus and capture them.
- **Collaborating across the ecosystem:** Building a successful hydrogen economy requires collaboration across upstream, midstream, and downstream operations. Complex global ecosystems are emerging, involving a range of new and incumbent players. Understand the opportunities and build partnerships to position your organization in key relevant areas, technologies, projects, and geographies.
- **Investing in innovation:** Embracing innovation in technologies, processes, and business models will help to differentiate, go beyond basic regulatory compliance, and allow price premiums.

**FLORENCE CARLOT**

is a Partner in Arthur D. Little's Brussels office and a member of the Energy & Utilities Practice.

**OLIVER GOLLY**

is a Partner in Arthur D. Little's Frankfurt office and a member of the Energy & Utilities Practice.

**CARLO STELLA**

is a Partner in Arthur D. Little's Dubai office and a member of the Energy & Utilities Practice.

**BENEDIKT UNGER**

is a Principal in Arthur D. Little's London office and a member of the Energy & Utilities Practice.

**THOMAS OOSTERLINCK**

is a Manager in Arthur D. Little's Brussels office and a member of the Energy & Utilities Practice.



**"SPEEDING UP THE ENERGY  
TRANSITION IS KEY:  
WE HAVE PUT OUR FOOT  
ON THE ACCELERATOR"**

# AN INTERVIEW WITH PASCAL DE BUCK



**PASCAL DE BUCK**

CEO AND MANAGING DIRECTOR OF FLUXYS

**Pascal De Buck (°1966) is the driving force behind Fluxys and its 1,300 employees. He joined the company in 1995, came on board the management team in 2008, and has been CEO and Managing Director since 2015. Pascal studied Law, Industrial Policy, and Financial Management, and also graduated in the IESE Business School's Global CEO Program.**

Headquartered in Belgium, Fluxys is a fully independent infrastructure group with 1,300 employees active in gas transmission & storage and liquefied natural gas terminaling. Through its associated companies across the world, Fluxys operates 24,000 kilometers of pipeline and liquefied natural gas terminals, totaling a yearly regasification capacity of 380 TWh. Among Fluxys's subsidiaries is Euronext, listed Fluxys Belgium, owner and operator of the infrastructure for gas transmission & storage and liquefied natural gas terminaling in Belgium.

As a purpose-led company, Fluxys, together with its stakeholders, aims to contribute to a better society by shaping a bright energy future. Building on the unique assets of its infrastructure and its commercial and technical expertise, Fluxys is committed to transporting hydrogen, biomethane, or any other carbon-neutral energy carrier, as well as CO<sub>2</sub>, accommodating the capture, usage, and storage of the latter.

## THE TRANSITION TO NET ZERO

The energy transition to enable net-zero targets by 2050 is a reality being addressed by the energy sector. This includes the global gas transport infrastructures that today provide reliable and consistent energy supply to industries and households across the world. These infrastructures will need to diversify and transform to do their part in helping to deliver on climate targets by providing means for transporting alternative gases, such as hydrogen and carbon dioxide from carbon capture.

We talked to the CEO and Managing Director of Fluxys, Pascal De Buck, to understand his perspectives on the contribution of the hydrogen economy toward achieving net zero.

## WHAT WILL IT TAKE FOR THE HYDROGEN ECONOMY TO CONTINUE TO GROW IN THE FUTURE?

We need to move, and to move now, to reach these targets. That means we must speed things up. As an essential infrastructure partner with our 1,300 employees across Europe, Brazil, and Chile, we are developing infrastructure for hydrogen and CO<sub>2</sub> to ensure a rapid scale-up of decarbonization solutions. The speed of the energy

***"INFRASTRUCTURES WILL NEED TO DIVERSIFY AND TRANSFORM TO DO THEIR PART IN HELPING TO DELIVER ON CLIMATE TARGETS."***

transition will – more than we can imagine today – largely impact the competitiveness of European industry, and thus employment. That is why every type of support, be it technological, financial, or legal, from the European Union is crucial. A regulatory

framework for both H<sub>2</sub> and CO<sub>2</sub> infrastructure is also key to ensure we reach the EU's 2030 CO<sub>2</sub> reduction targets. (Note: in May 2023, the hydrogen and decarbonized gas market package was not yet finalized.) At the same time, quickly decarbonizing our industries, ensuring the availability of enough low-carbon hydrogen, will be a challenge.

## HOW DO YOU SEE THE SYMBIOSIS OF ELECTRONS AND MOLECULES, PARTICULARLY IN THE EUROPEAN CONTEXT?

The answer lies in the word symbiosis. I am a strong believer in an integrated energy system where electrons (energy from electricity) and molecules (energy from gases) work together in a mutually beneficial relationship. I often refer to this symbiosis as an "and-and" approach for our future energy mix. By putting together the strengths

of carbon-neutral electricity and carbon-neutral molecules such as hydrogen, biomethane, synthetic methane, and biofuels, one can build an affordable, always-available, and sustainable energy system.

Some voices advocate for extensive electrification and minimizing key features of an energy system and the cost/benefit ratio of electrification in the long term. In view of security of supply, a more balanced energy mix with molecules is preferable. Imagine a factory fueled with wind power. On windy days there will be an abundance of energy, and on others a shortage. This instability of energy supplies from renewables can be absorbed, among others, through

interconnections, of course, but also diversification by molecules.

In addition, the outstanding power density of molecules such as hydrogen is one of the best ways to store and deploy renewable energy, as one does not want to see a single gust of wind go to waste.

***“IN TERMS OF THE POTENTIAL USE FOR HYDROGEN, WE SEE IT BEING USED TO FUEL INDUSTRIES, TO STORE RENEWABLE ENERGY, AND TO PRODUCE CHEMICALS.”***

The European Green Deal also refers to a 50/50 relation of electrons and

molecules in Europe’s energy mix by 2050. Recent developments in this area are promising. Together with the transmission system operators (TSOs) surrounding the North Sea – Energinet, Fluxys, Gascade, Gas Networks Ireland, Gassco, Gasunie, GRTgaz, National Gas Transmission, and OGE – we are working towards a balanced system of green electricity and green hydrogen from North Sea wind.

## **IN WHICH APPLICATIONS OF THE HYDROGEN INDUSTRY DO YOU SEE THE GREATEST POTENTIAL FOR GROWTH?**

Every industry that needs a constant flow of energy at an optimal cost should consider a diversified and balanced energy mix, plus, for some process industries, a combination with carbon capture.

In terms of the potential use for hydrogen, we see it being used to fuel industries, to store renewable energy, and to produce chemicals. By 2026, Fluxys’s first pipelines will be ready to transport hydrogen. This is the first step in our aim of establishing connections between industrial zones, as well as implementing connections with neighboring countries.

Let's also not forget carbon capture usage and storage (CCUS), one of the quickest ways to decarbonize some industries. Based on these interactions, we see a market potential by 2030 for Belgium, the North of France, and the industrial Ruhr-area in Germany of approximately 30 million tons of CO<sub>2</sub> per year. (Note: Belgium industry yearly puts out 40 million tons of CO<sub>2</sub>.) With Fluxys, we invest in an open-access infrastructure in close interaction with these markets.

## WHAT SIGNALS DO YOU HEAR IN THE MARKET, ON BOTH DEMAND AND SUPPLY?

We notice that industries are considering various solutions today. Some of these solutions are brought in as stand-alone technologies, and some in combination, because of, among others, the characteristics of an industrial process. I can think of low-carbon molecules, carbon capture usage and storage, and electrification. So many options are still open, and one has to be careful in advocating for one solution.

Our first interactions with the market currently show hydrogen demand in Belgium at a level of 15 to 20 TWh/y horizon by 2030. This confirms the 20–30 TWh/y range estimated in the study, informing the Belgian federal hydrogen strategy and pointing at a 100–200

TWh/y demand range by 2050.

***"OVERSEAS HYDROGEN DERIVATIVES IMPORTED BY SHIP ARE EARMARKED TO DEVELOP IN THE SECOND HALF OF THIS DECADE, AND THE FIRST GREEN HYDROGEN PRODUCTION FROM NORTH SEA WIND IS TARGETED FOR 2030."***

The hydrogen network we have on the table in Belgium is also set to quickly develop as a hub for Northwest Europe, linking directly to the Netherlands and France, and into Germany shortly after. Hydrogen flows into Germany are estimated at a level of up to 10 TWh/y in 2030, and up to 100 TWh/y in 2050. On the supply side, our interactions

with the market at this stage show projects for 10 to 25 TWh/y by 2030, combining electrolyzer capacity, blue hydrogen production, and cross-border flows. Overseas hydrogen derivatives imported by ship are earmarked to develop in the second half of this decade, and the first green hydrogen production from North Sea wind is targeted for 2030.



## HOW DYNAMIC IS EUROPE COMPARED TO THE REST OF THE WORLD?

Europe is taking a leading role in shifting to the climate goals set out in the Paris Agreement, and in achieving its “Fit for 55” targets, referring to the EU’s target of reducing net greenhouse gas emissions by at least 55 percent by 2030. With the war in Ukraine, the dependency on Russian gas has been at the center of all discussions. REpowerEU and several other policy steps taken by the European Union have determined the beat of the energy acceleration in Europe.



## FLUXYS HAS COMMUNICATED A LOT ABOUT H2 BEING A GAME CHANGER – HOW DO YOU PREPARE? HOW ARE YOU TRANSFORMING THE COMPANY IN THIS FUNDAMENTAL SHIFT? WHAT ARE YOUR INITIATIVES?

We have put our foot on the accelerator. As an essential infrastructure partner, we are developing infrastructure for hydrogen and CO2 to ensure a rapid scale-up of decarbonization solutions. This comes with ambitious targets we have set ourselves of offering a capacity of 30 TWh of hydrogen and of 30 million tons of CO2 a year by 2030.

At the same time, we will continue enabling the supply of natural gas to society at large for as long as is required.

To intensify our focus on energy transition projects, we have established a new business unit within Fluxys Belgium, called Fluxys nextgrid. At the center of Fluxys nextgrid’s mission is building the first transmission infrastructure for hydrogen/CO2 in 2026, and bringing to life terminaling projects for hydrogen and CO2 in Antwerp, Ghent, and Zeebrugge. In turn, partnering with industry, other TSOs, and international ports is the way forward.

Simultaneously, we are rolling out large-scale digitalization projects, developing digital solutions backed by robust business processes for our customers, employees, and other stakeholders.

## **HOW DO YOU SEE THE ROLE OF FLUXYS IN THE ESTABLISHMENT OF HYDROGEN?**

As an essential infrastructure partner putting emphasis on a network accessible to all and managed by a single operator in a regulated market.

As one team, we have set ourselves the ambition to accelerate this transition with a double mission: firstly, creating solutions for large-scale decarbonization through hydrogen and CO2 infrastructures, and secondly, providing the infrastructure needed for securing the supply of energy. This is how we provide continuity while speeding up towards a sustainable future.

***"THE ENERGY TRANSITION IS A MAJOR CHALLENGE FOR US ALL. AS ONE TEAM, WE HAVE SET OURSELVES THE AMBITION TO ACCELERATE THIS TRANSITION."***













**ARTHUR  LITTLE**