



REDUCING THE INVESTMENT AND OPERATING COSTS OF LOW CARBON HYDROGEN, FROM PRODUCTION TO DISTRIBUTION : A PREREQUISITE FOR MASS ADOPTION

Capgemini analysis based on a survey of over 100 companies and organizations in the H₂ sector

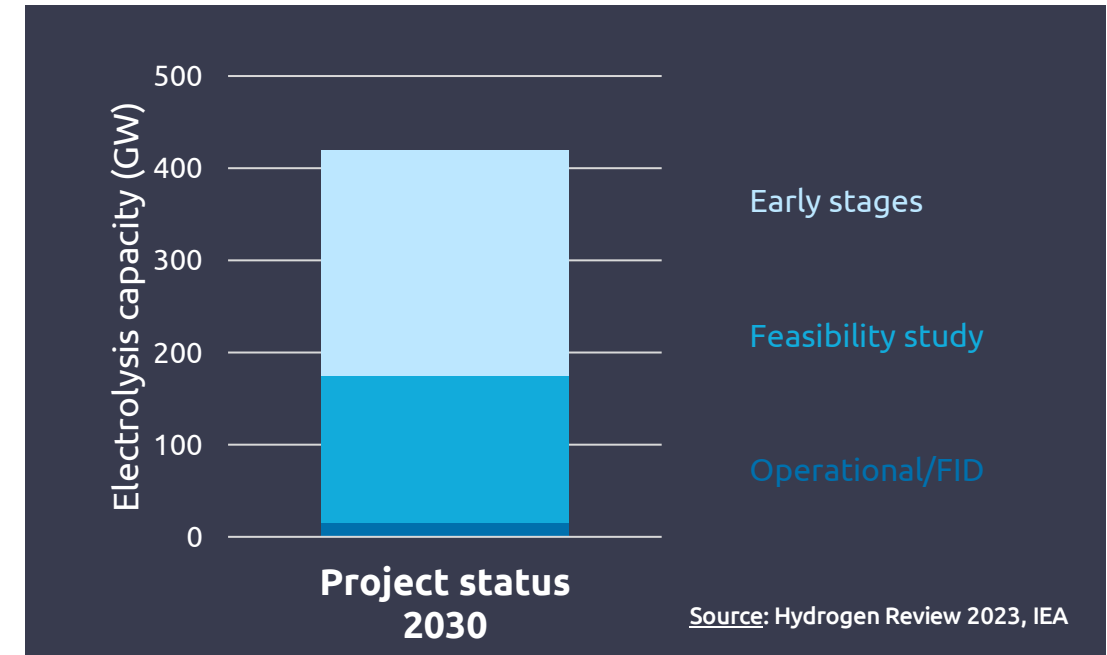
JANUARY 2024



AFTER A PERIOD OF GREAT ENTHUSIASM FOR THE SECTOR, THERE HAS BEEN AN AIR POCKET IN 2023

- According to the IEA, in 2023, **only 4% of projects have entered the Final Investment Decision (FID)**
- In addition, forecasts for the volume of low-carbon hydrogen are falling: the IEA has revised the Net Zero roadmap for 2023 **from 150 million tonnes of low-carbon hydrogen to 70 million tonnes.**

ELECTROLYSIS CAPACITY IN 2030 BASED ON ANNOUNCED PROJECTS



It is this stark disparity between expectations and tangible results that led us to dig deeper and commission this report



WE SURVEYED OVER +110 ORGANIZATIONS OVER THE WORLD TO ASSESS THIS SITUATION

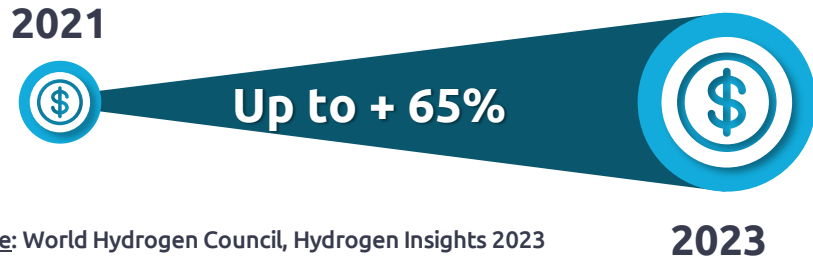


It should be noted that this analysis and survey were conducted across western markets. We provide a thorough assessment and also conduct a deep dive into possible levers that can be applied to reduce low-carbon hydrogen costs



FAR FROM PREVIOUS PREDICTIONS, LOW CARBON HYDROGEN REMAINS TOO EXPENSIVE, UNCOMPETITIVE AND PRICES UNCERTAIN

INCREASED HYDROGEN PRODUCTION COSTS

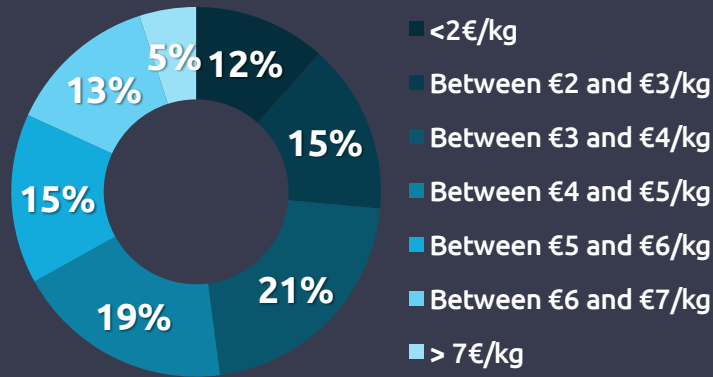


Source: World Hydrogen Council, Hydrogen Insights 2023

HYDROGEN PLAYERS AGREE THAT THE PRICE WILL DECREASE BELOW 7€/KG BUT THERE IS NO COMMON VISION, TRADUCING A LOT OF UNCERTAINTY

- This result is far from the previous prediction, with production prices expected below € 2 or 3/kg by 2030. The IEA's 2023 Global Hydrogen Review still maintains that green hydrogen could be produced in Europe for €1.60/kg by 2030
- There is today no common vision and real uncertainty, far from the previous prediction where a few years ago, the consensus view expected green hydrogen production costs below €3/kg. Today, 21 % of our respondents see the price between 3 and 4€/kg ; 19 % between 4 and 5€/kg.

PRICE PROJECTIONS FOR 2030



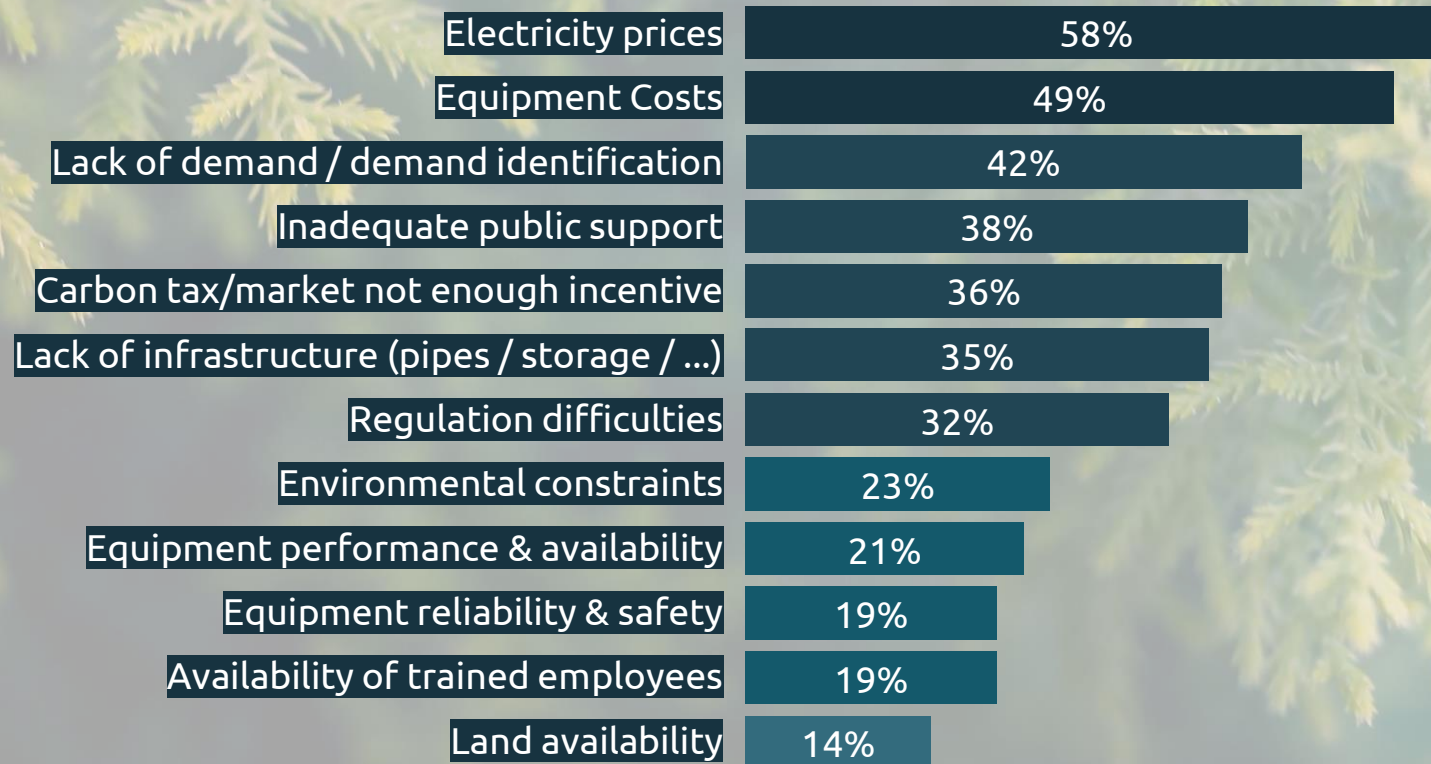
Source: Capgemini survey, 2024

This uncertainty is **depriving major market players of a common reference point for building business plans** around low-carbon hydrogen-based solutions and developing competitively priced projects.



PLAYERS ENCOUNTER STRONG DIFFICULTIES TO DEVELOP LOW CARBON HYDROGEN PROJECTS WITH A COMPETITIVE PRICE

DIFFICULTIES ENCOUNTERED TO OFFER COMPETITIVE PRICES, ACCORDING TO OUR SURVEY RESPONDENTS



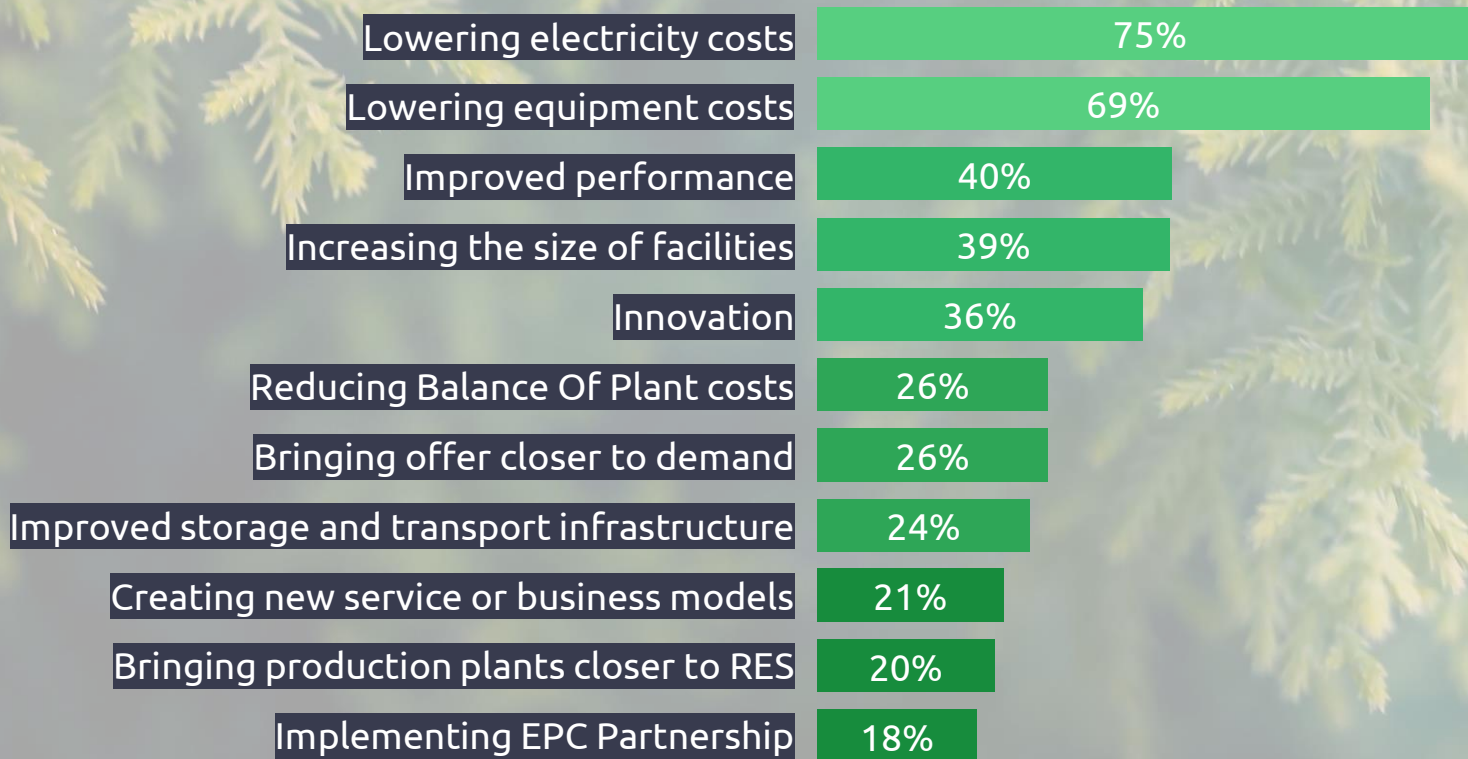
Source: Capgemini survey, 2024

- **Firstly, electricity prices** are a major difficulty. Today, the cost of electricity represents between 40 and 70 % of the LCOH, depending on the electricity price.
- **Secondly, lack of demand** remains a big issue as well as the **carbon price** which remains too low globally and the **inadequate public support directed towards offer**.
- **Then, equipment costs** are seen as a major difficulty which is the second most important cost factor with CAPEX representing 43% of the LCOH in our reference scenario.
- **Lack of employees with the right skill sets is not seen as a major difficulty** (only 19% of the respondents) – these moderate the previous job tension assumptions.



ENHANCING FLEXIBILITY, REDUCING ELECTRICITY COSTS AND LOWERING EQUIPMENT COSTS ARE THE KEY INTERNAL LEVERS TO REDUCE HYDROGEN COST

LEVERS THAT CONTRIBUTE THE MOST TO LOWERING PRICES, ACCORDING TO OUR SURVEY RESPONDENTS



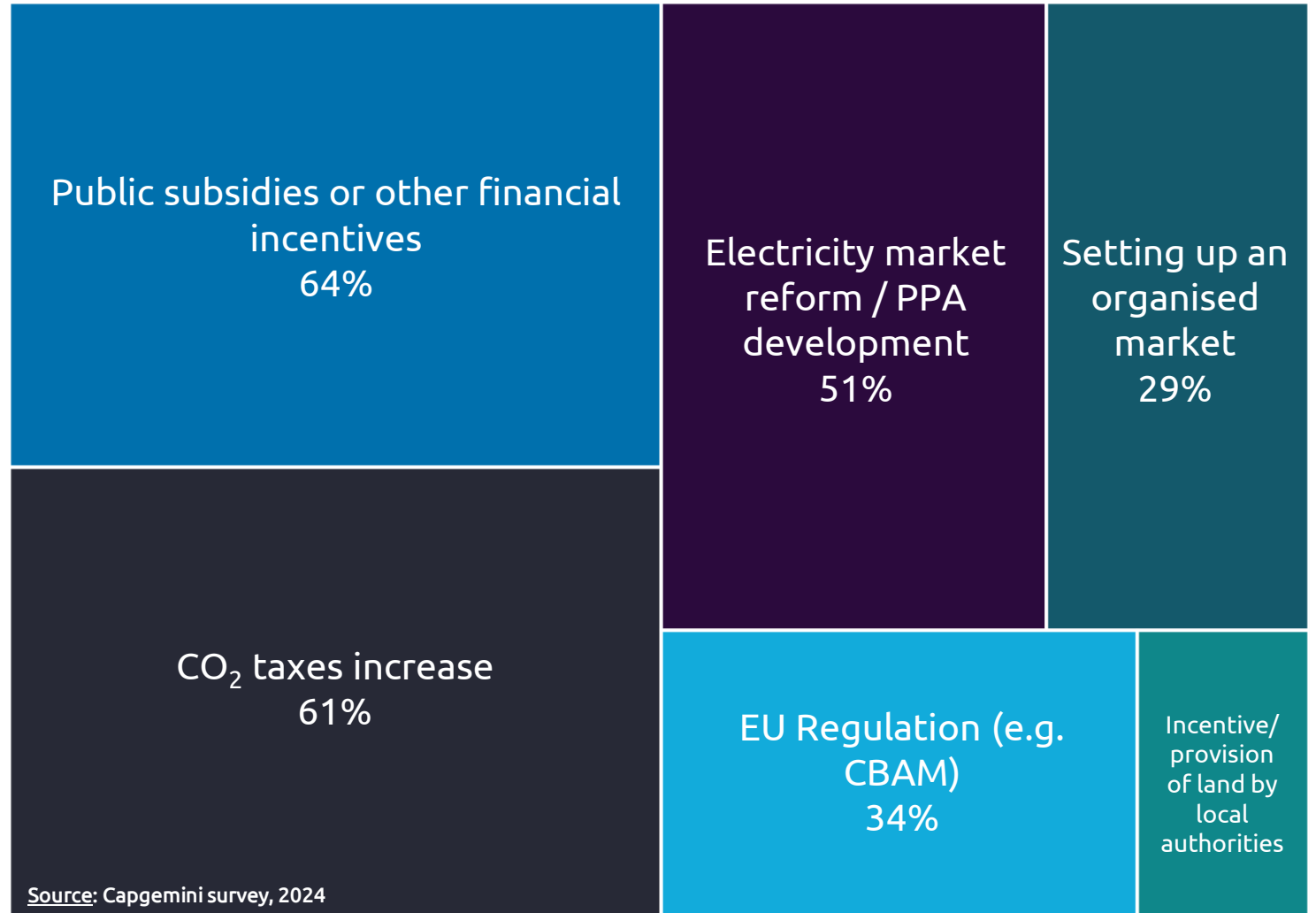
Source: Capgemini survey, 2024

- **Without surprise, lowering electricity cost comes first** (74% of respondents) with electricity purchasing strategy over the long term (PPA* contracts, diversification of renewable/low carbon electricity sources to increase electrolyser load factor) and the value of flexibility.
- **Lowering equipment costs comes in second:** indeed, **competitive equipment prices** and **equipment reliability** (36% of respondents) are key to carry out a hydrogen project at scale over the next years.
- **Lowering financial costs is not seen as a big potential lever** (26% of respondents) despite the current context of high interest rates. However, as the market becomes more mature, the broad availability of affordable debt will be pivotal for executing capital intensive low carbon hydrogen projects.



EXTERNAL LEVERS ARE ALSO ESSENTIAL TO MAKE LOW CARBON HYDROGEN COMPETITIVE AGAINST OTHER ENERGY VECTORS

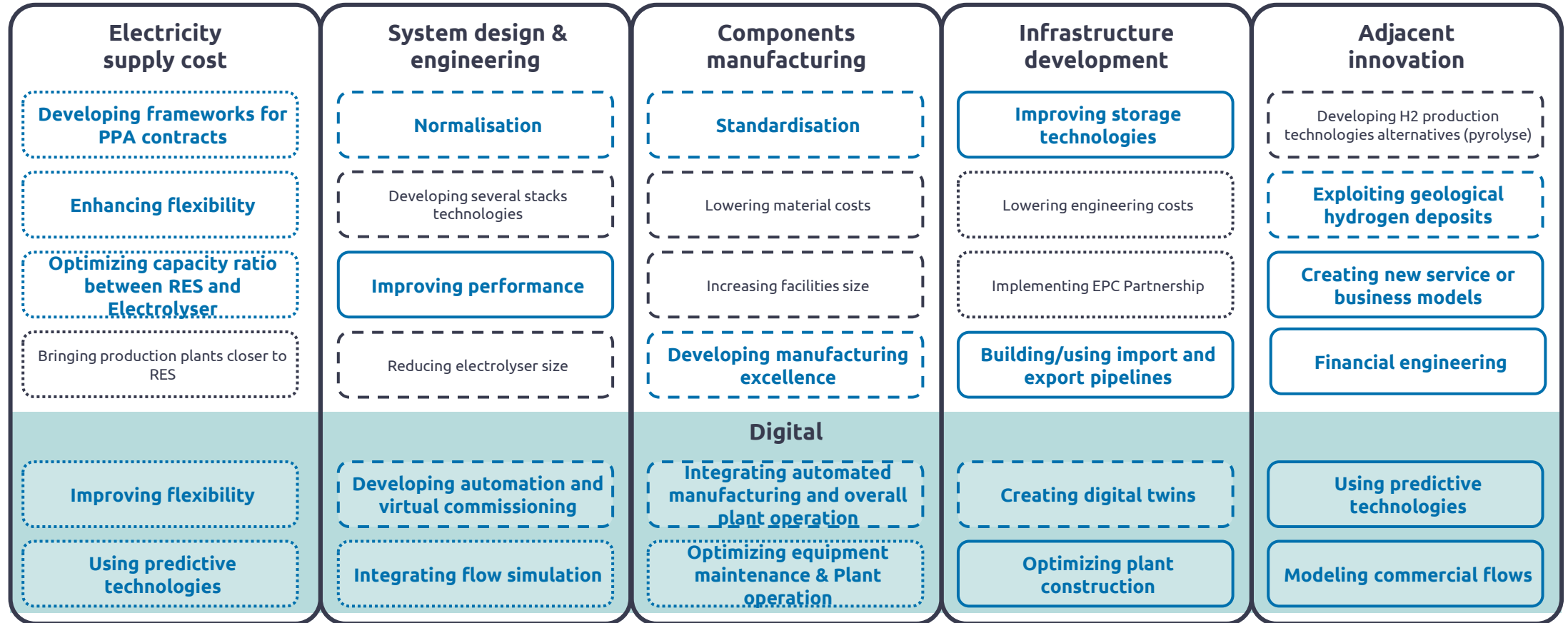
- **Public support is key to support the demand that remains focused on traditional applications.** Indeed, offtake contracts are key while allocations of public aid remain slow, particularly in the European Union with IPCEIs. It is however starting to be considered with the launch of several auctions and contracts for difference (CFDs) worldwide.
- **The increase of CO₂ taxes and a reform of market electricity reform to develop more Power Purchase Agreement (PPA*)** are seen as essential by the respondents of our survey.



*PPAs : Contracts where a buyer agrees to purchase a power from a producer at a predetermined price over a long period.



ALTHOUGH UNDERESTIMATED, DIGITAL IS A KEY ENABLER TO REDUCE HYDROGEN COST AND CARRY OUT PROJECT AT SCALE



Source: Capgemini analysis, 2024

xx Key levers

Impact on CAPEX

Impact on OPEX

Impact on both

Only 1% of the respondents believe digital as a major lever however digital has an impact from system and component design phase to project operation



INNOVATION IS AN UNDERRATED LEVER THAT NEEDS TO BE ACTIVATED FOR A GAME-CHANGING IMPACT

36% of the respondents believe innovation will contribute the most to lowering hydrogen prices.

High temperature electrolysis is a promising technology while **electrolysers** is a key aspect of the value chain to be developed in the next years

53% of the respondents

Developing other low carbon production technologies, including extraction of geological hydrogen, is less being considered, but the sector remains alert to possible innovations

32% of the respondents

Certification via digital could facilitate the market development : traceability is key to create a market and foster the deployment of guarantee of origin

49% of the respondents

Source: Capgemini survey, 2024