

Executive summary

On behalf of Arena H2 Cluster and partners, Menon Economics has conducted a study that presents an overview of the current state of the hydrogen industry, as well as industry players' expectations towards 2030. This report focuses on mapping employment, revenues, investments and growth outlooks for industry players currently developing projects. The report is divided into the following three main parts:

- **Part 1:** State of the Norwegian hydrogen industry and projects under development
- **Part 2:** Ambitions and expectations of the Norwegian hydrogen industry towards 2030
- **Part 3:** Norwegian market players' competitive advantages and barriers for growth, as well as criteria for success

Hydrogen and ammonium are key for the green transition towards a low-emission society

The world is facing severe consequences of climate change, and nations, through the Paris Agreement, have committed to limiting these changes. If the global community is to reach the goals set out in the Paris Agreement, major transformation of the world economy is needed. This is particularly true for the manner in which we consume and produce energy. The transition to a low-emission society presents not only a great challenge, but also economic opportunities for nations that are able to quickly enact structural change. Hydrogen and ammonium are expected to be critical components for this structural transition as they are energy carriers that hold a wide range of applicability. This is also reflected in a substantial revenue potential globally, regionally as well as nationally. In Europe the hydrogen market (sale of hydrogen) may reach revenue levels of up towards 1,500 billion NOK in 2050 according to Aurora Energy Research. The EU itself has expressed an investment need of between 2,000 and 4,000 billion NOK (in Europe) towards 2050.

The largest uncertainties surrounding the hydrogen market today are government climate ambitions, the development of competing low emissions technologies and the energy crisis. The signals from the EU are however clear: hydrogen is to be a key energy carrier in the road towards a low-emission society. In REPowerEU, the EU's strategy for speeding up towards the green transition and reducing its dependence on Russian gas, hydrogen is referred to as the "backbone of the energy transition". With this, the EU has stated a goal of producing 10 million tonnes of hydrogen in EU countries as well as an import of 10 million tonnes within 2030. Norwegian authorities also point to hydrogen as a strategic area of investment, latest expressed in the government's *Roadmap – The green industrial initiative* launched in the spring of 2022. The government has an ambition to develop a complete value chain for production, distribution and utilisation of hydrogen produced with zero or low emissions.

The Norwegian hydrogen industry is currently of limited size, but holds large potential

The Norwegian hydrogen industry consists of equipment and technology distribution, service providers, hydrogen and ammonium production as well as distribution. Equipment and technology distributors and service providers currently make up the majority of the industry today, closely followed by production, when measured in number of companies present in Norway. Our estimates show that the hydrogen industry generated a total revenue of 1.47 billion NOK in 2021. A larger share of this revenue, close to 70 per cent, was export or revenue generated in subsidiaries abroad. Further, the industry employed 815 full time equivalents (FTE's) in 2021. The revenue generated is primarily driven by equipment or technology distributors that cater to a global market. The remaining part of the industry is characterized by a larger number of companies who are in the early stages of

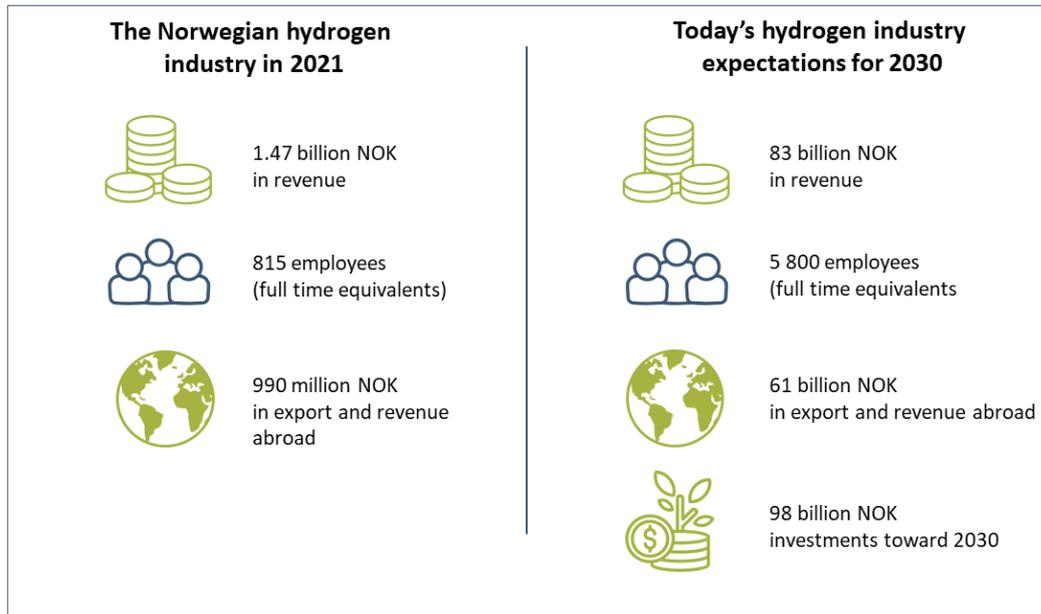
developing their business opportunities within hydrogen, where only a limited share of the employees is dedicated to this work.

Despite the hydrogen industry as a whole being of relatively limited size today, it consists of ambitious industry players where the majority are targeting market segments with substantial growth potential. This is made clear by the fact that a substantial share of today's activities is related to development of new projects. Our mapping shows that there were 59 hydrogen and ammonium projects under development in Norway during the fall of 2022. These are projects set on building production facilities for hydrogen/ammonium, as well as building or expanding production units for equipment that are part of production processes or application. The majority of the projects under development are set on production of hydrogen. In several of these projects there are plans for both establishing hydrogen production as well as facilitating bunkering and distribution. We find fewer projects that plan to build new equipment factories or expand production capacities of current facilities. It is however important to point out that there are planned projects of substantial size within this segment of the value chain. A majority of the projects identified in this study is located in Western and Northern Norway (Vestlandet and Nordland), as well as in Vestfold and Telemark.

In the project portfolio we have identified a potential production volume of around 3,300 tonnes of hydrogen daily by 31 projects whose intent is to establish hydrogen production facilities. These levels of production imply a yearly production of closer to 1.2 million tonnes. Further, we have identified six ammonium production facilities, that together will hold a capacity to produce around 5,200 tonnes of ammonium daily, or 1.8 million tonnes yearly. The ammonium portfolio under development is in other words characterised by fewer projects, but where each project is of substantial size. The total market value for these projects is estimated to 30-60 billion NOK yearly, depending on price developments.¹ These estimates are based on the assumption that all the identified projects will be completed. It is important to point out that there will be competition between individual projects that, for example, plan to establish themselves in the same location and supply the same markets. This could lead to some projects not being completed. In addition, elements such as today's high power and gas prices and market uncertainties can lead to delays or cause projects not to be completed. However, it is important to point out that we also have identified several Norwegian players that expect investment in production facilities outside of Norway. This type of Investments will contribute directly to value creation in Norway, but employment effects will be more limited. Production capacity and "Norwegian shares» for this portfolio have not been successfully identified in this year's report. However, industry players' expected collective investments are presented below.

¹ Estimate based on expected yearly production and a range of potential future prices based on Bloomberg and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping.

Key figures for the hydrogen industry in 2021 and market expectation for 2030



Today's hydrogen industry expects substantial growth towards 2030

Today's Norwegian hydrogen companies are involved in a series of projects under development and are actively investing in building a Norwegian hydrogen industry. This is reflected in their expectations for own growth in the coming decade. Our mapping shows that hydrogen players' expectations for revenue and employment makes up 83 billion NOK and 5,800 FTE's in total, respectively. Expectations for revenue growth are especially high within production and distribution, which is closely related to the composition and size of today's project portfolio. In cadence with developing the local market, industry players expect to increase activities abroad. The industry's total expectation for export and revenue abroad in 2030 is estimated to 61 billion NOK, which corresponds to a share closer to 75 per cent of total revenue. Europe, Asia and North America are expected to make up important markets going forwards, while maritime transport and operations is expected to be the most important market segment, followed by industry and land transport. The Norwegian hydrogen industry and especially hydrogen production is characterised by high levels of productivity. Our estimates show that the industry's expectation will lay the foundation for value creation of up towards 20 billion NOK, which implies a value creation per employee of 3.6 million NOK. For reference, the average value creation per employee in the Norwegian mainland industry is 1.1 million NOK.

The industry's investment activities will affect the industry's size in the years to come. Our estimates indicate that market players in today's hydrogen industry expect to carry out investments that in total make up 98 billion NOK toward 2030. 45 per cent of respondents in our survey state that they will invest in hydrogen and/or ammonium production within this decade. Seeing how capital-intensive investments in production capacity will be, this implies a substantial share of the industry's expected investments to be focused on production capacity. In this context it is important to point out that there will be competition between the projects planned, and it is likely that not all projects will reach their expectations. At the same time, we expect that the hydrogen industry will grow across the value chain towards 2030, which widens the scope of business opportunities. Despite the underlying uncertainty surrounding future revenues, our estimates provide meaningful insight regarding ambitions and the potential for the industry. Our estimates may also serve as benchmarks for the industry going forwards toward a fully operational and commercialised value chain for hydrogen and ammonium in Norway.

The Norwegian hydrogen industry has multiple competitive advantages, but certain barriers may hinder the potential

The Norwegian hydrogen industry expects large growth, both domestically and in export markets. But what competitive advantages do Norwegian companies have, what barriers do they face, and what are criteria for success in building a competitive hydrogen industry? Norway is an energy nation, and a substantial share of today's industry is based on refinement of local energy resources. Access to renewable energy and natural gas is also identified by hydrogen companies as one of Norway's biggest competitive advantages. As significant growth in energy use is expected towards 2030, this also reflects that it is expected that access will be maintained in the medium to long term. On the other hand, we find lack of access to a relevant workforce and infrastructure for distribution, storage and transportation, as well as lack of demand. These are barriers the market players see as most critical to address in order to reach the revenue potential present. The latter point is also reflected in how the projects we have mapped are set up. A substantial share of hydrogen projects planned are either to be part of existing production lines or to be sold to a specific vessel, rather than being a commodity sold on the open market.

Clear ambitions and conditions set by authorities, as well as demand and willingness from the private sector will be needed

Local market players point to the need for clear long-term ambitions both from Norwegian and European authorities. This is expected to reduce market uncertainties and risk for the private sector. The ambitions will however need to be followed up by concrete actions within industrial development and climate policy. In particular, emissions pricing (in relevant markets) and establishing economic support systems are relevant actions from the perspective of national and international authorities. In addition, industry players point towards a need for a large-scale willingness for transformation and investment, both in the industry itself, in adjacent industries and in end user markets. Further, a cooperative approach is key. Development of an ecosystem with a wide range of players will support cooperative endeavours in developing and scaling new projects and solutions, leading to long term growth in the Norwegian hydrogen industry.