WHITE PAPER · TECHNOLOGY AND INVESTMENT REVIEW · GREEN HYDROGEN

Flexible electrolysis for low-cost green hydrogen

shiptown®'s 44 kWh/kg paradigm-shifting electrolyser: the technology, the economics of European power markets and the investment case

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15 November 2026 · 100 MW reference plant · 44 kWh/kg (LHV 75.8%) at 35 bar(g) · capex €1,600/kW fully installed · 10%/yr capital charge · day-ahead prices Oct 2023 – Sep 2026



Photo: shiptown A/S

Techno-economic review based on company information and public market data. Company statements are reported as such. Not investment advice; see the disclosure on page 2.

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TECHNOLOGY REVIEWED

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Disclosure. Stephen B. Harrison of sbh4 consulting is Strategic Advisor to shiptown A/S, as listed in shiptown's investor presentation of October 2026. Readers should take this relationship into account. [To complete before release: nature of any remuneration, options or shareholding.]

To keep the analysis neutral, this paper (1) reports shiptown's technical statements as company statements; (2) tests the company's economic statements with sbh4's own models and public market data and shows both where they differ; and (3) benchmarks shiptown against named commercial electrolysers on identical assumptions.

Basis of the numbers. Levelised cost of hydrogen (LCOH) is in € per kg of hydrogen at the plant outlet, for a 100 MW plant (rectifier AC input). Unless stated otherwise: shiptown at 44 kWh/kg with hydrogen delivered at 35 bar(g), a fully installed capex of €1,600/kW, an annual capital charge of 10% of capex and power bought in the cheapest hours of the year at day-ahead prices from October 2023 to September 2026 plus 2026 grid fees, taxes and levies. Comparisons with other electrolysers are for hydrogen delivered at 30 bar(g) or more. Electrolyser O&M, stack replacement, water, storage and subsidies are excluded.

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SECTION 1

Executive summary

44 kWh/kg
shiptown's stated system consumption at the site boundary, 35 bar(g), >99.9% purity (75.8% LHV, 89.6% HHV)

€3.82/kg
Lowest LCOH in Germany, at 4,000 h/yr with all grid charges (John Cockerill DQ1000: €5.66/kg)

€1.54–2.17
per kg: lowest LCOH in NO4, SE1 and Finland at a 10%/yr capital charge (€1.01–1.44 at 5%)

23%/yr
pre-tax return on capital, 100 MW in Germany at 4,000 h/yr and €7/kg; simple payback 3.6 years

Key findings

- **Efficiency is the headline statement and the first diligence item.** shiptown states 44 kWh/kg at the site boundary, with hydrogen at 35 bar(g). The three commercial systems benchmarked here need 52.2 to 55.6 kWh/kg. If 44 kWh/kg is confirmed at scale, the same 100 MW grid connection produces about 26% more hydrogen than a 55.6 kWh/kg system. shiptown reports 90% system efficiency (HHV basis), about 43.8 kWh/kg, measured on a five-cell stack, so the figure still has to be demonstrated at module scale.
- **Flexibility turns cheap hours into cheap hydrogen.** From October 2023 to September 2026 the cheapest 4,000 hours of each year cost €47/MWh all-in in Germany, €26/MWh in Spain and €13/MWh in Finland. Firm, round-the-clock power from a dedicated wind, solar and gas plant would cost €102–128/MWh in the three regions modelled, and gas-only supply €167–174/MWh.
- **LCOH is low and, in Germany and Denmark, flat.** With a fully installed capex of €1,600/kW, a 10%/yr capital charge and all grid charges included, shiptown's LCOH reaches €3.82/kg in Germany, €2.80–2.90/kg in France and Spain and €1.54–2.17/kg in the Nordic zones. In Germany and DK1 it varies by no more than 16% between 2,000 and 8,000 h/yr, so the plant can follow the market without a cost penalty.
- **shiptown is €0.94–1.95/kg cheaper than a pressurised alkaline benchmark.** Against the John Cockerill DQ1000 (€2,300/kW fully installed, 55.6 kWh/kg, 30 bar(g)), each at its own cost-optimal operating hours, the saving ranges from €0.94/kg in NO4 to €1.95/kg in DK1. In Germany at 4,000 h/yr, about 73% of the saving comes from lower capex per kg and 27% from lower electricity use.
- **The company's LCOH statements hold in the base case.** At a 10%/yr capital charge with grid charges, the LCOH curve stays within 20% from maximum to minimum over wide operating windows in every zone (2,000 to 8,000 h in Germany and DK1), LCOH is below €2/kg in SE1 and NO4, and it is below €4/kg in six of the seven zones; only DK1, at €4.18/kg, stays above.
- **The German case is resilient to the hydrogen price.** At €7/kg a 100 MW plant running 4,000 h/yr makes €29.0m/yr after a 10% capital charge (ROCI 23%). At €5/kg it still makes €10.8m/yr (ROCI 12%). These figures exclude O&M, stack replacement and tax, and assume today's German grid-fee and levy exemptions, which apply only to plants commissioned by 2029.
- **Maturity is the main risk.** shiptown reports TRL 4 completed and TRL 5 in progress, targets TRL 6 in mid-2028 and bankable equipment for 100 MW projects with commercial operation from 2030. Verified system efficiency, durability under daily cycling and manufacturing cost at scale are the critical path.

> **Implication for investors.** If shiptown's efficiency and capex statements are confirmed at module scale, the technology offers a structural cost advantage of around €1–2/kg over today's pressurised alkaline systems, and that advantage is largest where power prices are volatile, as in Germany and Denmark. The investment case therefore rests less on market assumptions than on technical validation: system efficiency at the site boundary, durability under daily cycling and manufacturing cost. The €6 million capital raise planned for 2027 targets exactly these steps.

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SECTION 2

Introduction: shiptown's technology in 46 points

In November 2026 shiptown A/S, a Danish developer based in Fredericia, summarised its electrolyser technology and plans in 46 points. This section explains them in plain terms, groups them by theme and notes, for each group, why the points matter to a project developer or investor and how they can be checked.

Numbers in brackets, for example (1), refer to shiptown's list, which is reproduced in Annex A with an evidence status for every point. Unless stated otherwise, the points are company statements that sbh4 has not verified independently. The economic statements (27–29) are tested with sbh4's own models in Section 7.

Efficiency and hydrogen quality

shiptown states a specific energy consumption of 44 kWh of electricity per kg of hydrogen, measured at the site boundary, for hydrogen supplied at 35 bar(g) and more than 99.9% purity (1). That is 75.8% efficiency on a lower heating value (LHV) basis and 89.6% on a higher heating value (HHV) basis. By comparison, the three commercial systems benchmarked in this paper need 52.2 to 55.6 kWh/kg.

shiptown compares its figure with the values that developers of water-fed solid oxide electrolysis (SOEC) systems have published. Its argument is that it reaches comparable efficiency with hydrogen delivered at pressure and with a more robust and more manufacturable cell and stack (2). It makes the same comparison with one or two other start-ups with innovative electrolyser technologies, highlighting delivery at 35 bar(g) from a system designed to PN63, a nominal pressure of 63 bar(g) (3).

Three design features are given as the reasons. The cell runs hotter than state-of-the-art alkaline systems, which raises the conductivity of the alkaline electrolyte (12). The cell architecture is very simple, with a zero-gap design and direct contact between electrode and bipolar plate, which minimises ohmic losses (23). And the investor presentation of October 2026 highlights 'bubble-free' operation as a core feature. No catalysts are used today; adding them is a possible future improvement (22).

Because 44 kWh/kg is above the thermoneutral energy of water splitting (39.4 kWh/kg, equal to the HHV), the process produces surplus heat in operation, consistent with the statement that no external heat is needed during ramp-up or operation (13).

Why it matters. Each kWh/kg saved is worth about €0.05/kg at a power price of €50/MWh, and because capex is paid per kW of input, higher efficiency also spreads the capex over more kilograms (Section 3). **How to check it.** shiptown reports 90% system efficiency (HHV basis), about 43.8 kWh/kg, measured on a five-cell stack, in line with the stated 44 kWh/kg. A full module also has to cover rectifier and auxiliary loads at scale, so independent measurement at module scale, on a clearly defined site-boundary basis, is the first diligence priority.

Cell architecture, safety and robustness

Oxygen and hydrogen are produced at separate locations in the cell, with three layers of the cell architecture between them (10). Electrical insulation between the electrodes is provided by a ceramic-type material rather than a polymer membrane or diaphragm, which permits the higher operating temperature (11). shiptown describes the design as intrinsically safe, with several physical mechanisms that keep the gases apart (14), and as tolerant of an instantaneous loss of power, for example when an electrolyser is tripped to provide grid-balancing services or to meet proposed EU rules on shut-off times (25). It reports no noticeable stack degradation or efficiency loss in flexible, load-following operation with frequent shutdowns (30), and regards the cell and stack as a new architecture unlike any other on the market (31).

Why it matters. Gas crossover at low load limits how flexibly conventional alkaline electrolysers can operate, so robust gas separation underpins the flexible operating strategy analysed in this paper. **How to check it.** Degradation statements need long-duration evidence: thousands of operating hours and many start-stop cycles, logged and reported in a form that lenders and insurers accept.

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Flexibility

shiptown states that the system tolerates unlimited starts and stops per day and per year, so it can follow renewable output without a large battery energy storage system (BESS) (18). Warm standby needs less than 5% of nominal power (19); in cold standby, power is needed only for the control and safety systems (20). Electrical input can be ramped fully up or down in less than 10 seconds, while gas output follows within tens of seconds to a few minutes as the system pressurises or depressurises (26).

Why it matters. This is what the economics in Sections 4 to 8 rely on: a plant that buys only the cheapest hours starts and stops often, typically daily. Standby energy belongs in the project model: holding a 100 MW plant warm at up to 5% of rated power uses up to 5 MWh in every standby hour.

Materials, water and environment

No platinum-group metals (PGMs) are used in any component (15), and no per- and polyfluoroalkyl substances (PFAS), including in gas-tight seals (16). Critical components use commonly available materials and industrial manufacturing processes (17). The alkaline electrolyte operates at a pH, and the cell at a temperature below 120 °C, that allow commonly available grades of steel (21, 24). Total water consumption is stated to be equal to or lower than any state-of-the-art electrolyser, with no cooling water required (7), which also suits hot and humid sites (8).

Why it matters. PGM supply is concentrated in a few countries and the EU has been evaluating a broad restriction of PFAS, so avoiding both reduces supply-chain and regulatory risk. **How to check it.** The surplus heat has to be rejected without cooling water; the method and its auxiliary power should be confirmed and included in the 44 kWh/kg boundary.

System design, pressure and maintenance

Hydrogen leaves the stack at pressure, so no compressor and no interstage cooling water are needed to supply hydrogen at pressure (9). shiptown states delivery at 35 bar(g) (1), and the system is designed to PN63, a nominal pressure of 63 bar(g) (3). The system architecture is simple, with minimal balance of plant and a very compact footprint (32). A 20-foot container module holds 40 stacks, and individual stacks can be ‘hot-swapped’ for inspection or maintenance while the module keeps supplying hydrogen (33).

Why it matters. Delivery at 35 bar(g) suits many industrial users without a compressor, and users who need more start compressing from 35 bar(g) rather than from near atmospheric pressure. **How to check it.** Delivery pressure and purity at full and part load, and the PN63 design basis and certification.

Cost, manufacturing and supply chain

The bill of materials for cell, stack and system is complete and costed (5), and the assembly line for stacks and containerised modules has been designed, sized and costed (37). shiptown expects equipment capex equal to or below that of the lowest-cost technologies available today and targets a fully installed capex of €1,600/kW (6), with a high share of European content in components and assembly (4). That share is aimed at ‘Made in Europe’ preferences in public procurement and support schemes, such as those in the Industrial Accelerator Act (IAA) proposed by the European Commission in March 2026, and at maximising EU capex and opex grants.

Why it matters. Capex is the second key variable after efficiency. The €1,600/kW used for shiptown in this paper is based on shiptown’s costed bill of materials and is a fully installed capex for typical European locations; the equivalent for the John Cockerill DQ1000 pressurised alkaline benchmark is €2,300/kW. €1,200/kW is shown as a sensitivity. **How to check it.** The bill of materials, assembly-line costing and installation-cost basis.

Economics

For direct grid connection and actual day-ahead prices of recent years, shiptown states that its LCOH curve is very flat (27), that LCOH is below €2/kg in the most attractive European bidding zones (28) and that it is below €4/kg in many European locations (29). Section 7 tests these statements with sbh4’s model at 44 kWh/kg and €1,600/kW: all three hold in the base case.

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Maturity, intellectual property and roadmap

shiptown has completed technology readiness level (TRL) 4 and is building equipment to complete TRL 5 (35). It is validating critical component designs and manufacturing tolerances and screening manufacturing partners (36). TRL 6 is planned for completion in mid-2028; the test site is confirmed, construction partners are involved and grant funding is secured for the whole consortium (38). shiptown expects to deliver bankable equipment able to support 100 MW projects with commercial operation dates (COD) from 2030 (34). Proprietary aspects are protected by patents (39); the October 2026 presentation cites more than 20 patent applications, including five international (PCT) filings.

Why it matters. Moving from TRL 5 to bankable 100 MW projects in about four years is a demanding timeline, and it sets the pace at which the cost advantages shown in this paper can be realised.

Platform beyond electrolysis

The same principles can be applied to a fuel cell with a similarly robust, safe and simple cell architecture (40). shiptown's reversible H-Battery, which uses one stack for both electrolysis and fuel-cell operation, is its longer-term product for long-duration electricity storage. This paper does not assess it.

Organisation, backing and financing

shiptown describes an uncomplicated board structure with rapid decision-making (41), and a company led and staffed by people with decades of industrial experience in renewables and electrolyser development: in its own words, 'a start-up run by grown-ups' (42). European Energy is an investor and strategic technology development partner (43). Advisors and board members bring current or previous experience at Stiesdal, Green Hydrogen Systems, Ørsted, European Energy, Rambøll, Linde and sbh4 (44).

Two financing steps are planned. In 2027, €6 million will be raised for materials optimisation, cell validation, screening of critical component manufacturing partners, stack building and bankability-grade testing of pre-production stacks built to a 'locked-down' design from components made by confirmed long-term partners (45). At the end of the decade, a further €18–20 million is to fund scaled component production, system assembly and full go-to-market execution, including business development, customer acquisition, project support and after-sales service (46).

The 46 points at a glance

Theme	Points	shiptown's position in brief	What to verify
Efficiency and quality	1–3, 12, 13, 22, 23	44 kWh/kg at 35 bar(g) and >99.9% purity, comparable with SOEC and other new concepts	Module-scale efficiency on a site-boundary basis
Architecture and safety	10, 11, 14, 25, 30, 31	Ceramic-type insulation, separated gas production, no noticeable degradation	Gas purity at low load; degradation under cycling
Flexibility	18–20, 26	Unlimited starts and stops, ramp in under 10 s, warm standby below 5%	Cycling data; standby energy
Materials and water	7, 8, 15–17, 21, 24	No PGMs or PFAS, common steels, no cooling water	Heat rejection method and its power
System design	3, 9, 32, 33	No compressor: 35 bar(g) delivery from a PN63 design; compact; 40 stacks per container, hot-swappable	Pressure at full and part load; PN63 certification route
Cost and supply chain	4–6, 37	Costed bill of materials; €1,600/kW fully installed targeted; high EU content	Bill of materials, assembly-line cost, installation-cost basis
Economics	27–29	Very flat LCOH; below €2/kg in the best zones and below €4/kg in many locations	Tested in Section 7: holds in the base case
Maturity and roadmap	34–36, 38, 39	TRL 5 under way, TRL 6 in mid-2028, 100 MW projects from 2030	Results at each scale-up step
Platform	40	Fuel cell and reversible H-Battery from the same principles	Not assessed here
Organisation and financing	41–46	Experienced team, European Energy backing; €6m raise in 2027, €18–20m at end of decade	Runway, governance, partner terms

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SECTION 3

Efficiency and technology in context

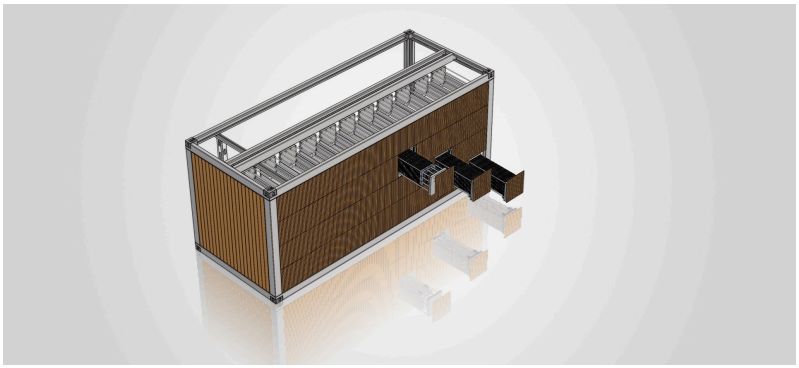

Figure 1. Containerised stack module, render (shiptown A/S, October 2026). Each 20-foot container holds 40 stacks (33).

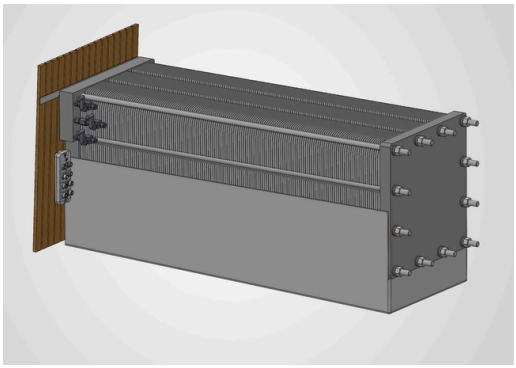

Figure 2. shiptown stack, render (shiptown A/S, October 2026).

Splitting liquid water at ambient conditions takes 39.4 kWh of energy per kg of hydrogen, the higher heating value (HHV). At least 32.7 kWh/kg must be electrical; the balance can in principle come from heat, which is how high-temperature electrolysis reduces its electricity demand. In an electrolyser supplied only with electricity, everything above 39.4 kWh/kg ends up as heat: cell overvoltage, ohmic resistance, rectifier losses, gas treatment and auxiliary loads. Efficiency is normally quoted against the lower heating value (LHV, 33.3 kWh/kg). Today's commercial PEM and alkaline systems run at roughly 60 to 64% LHV at system level (Table 1). shiptown's stated 44 kWh/kg corresponds to 75.8%.

Table 1. Four electrolyser options for a 100 MW plant delivering hydrogen at 30 bar(g) or more

System	Installed capex €/kW	Electrolyser kWh/kg	Efficiency % LHV	Outlet bar(a)	Compression kWh/kg	Overall incl. compression	Output kg/h
Siemens Energy Elyzer P-300 (PEM)	2,500	52.2	63.9%	1.05	1.93	61.6%	1,916
thyssenkrupp nucera scalum (atmospheric AWE)	2,300	54.5	61.2%	1.3	1.80	59.2%	1,835
John Cockerill DQ1000 (pressurised AWE)	2,300	55.6	59.9%	31	0.00	59.9%	1,799
shiptown (company statement)	**1,600**	**44.0**	**75.8%**	**36**	**0.00**	**75.8%**	**2,273**

Vendor datasheets for the commercial systems; shiptown company statement, November 2026. Capex is fully installed in typical European locations: shiptown's figure is based on its costed bill of materials, the others are sbh4 estimates. Compression to 31 bar(a): four-stage reciprocating compressor, 75% isentropic and 95% motor efficiency. The pressurised systems need no compressor; shiptown delivers at 35 bar(g).

Efficiency counts twice

A lower specific energy consumption cuts the electricity bill per kg. Less obviously, it also cuts the capital cost per kg, because electrolysers are sized and priced per kW of electrical input: a 100 MW shiptown plant at 44 kWh/kg would produce 2,273 kg/h against 1,799 kg/h for the 55.6 kWh/kg DQ1000, about 26% more from the same grid connection.

At 4,000 h/yr in Germany, where the cheapest 4,000 hours cost €46.7/MWh all-in, the two effects are worth €0.54/kg in electricity and €1.44/kg in capital charge (€1,600 against €2,300/kW at 10%/yr). In this model LCOH is directly proportional to kWh/kg: a 10% error in specific energy consumption is a 10% error in LCOH.

Delivery pressure

shiptown states delivery at 35 bar(g) (1) from a system designed to PN63 (3), and reports pressure testing above 35 bar. The comparisons in this paper are for hydrogen at 30 bar(g), the outlet pressure of the DQ1000; the two atmospheric systems include a compressor to reach it. shiptown exceeds that pressure without a compressor, and no credit is taken for the extra 5 bar.

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SECTION 4

What a flexible electrolyser pays for power

Electricity is the largest cost of electrolytic hydrogen: for shiptown in Germany it is 54% of LCOH at 4,000 h/yr and 80% at 8,000 h/yr. A plant that can start, stop and ramp freely does not have to buy power in every hour: it can buy only the cheapest ones.

Figure 3 shows how many hours per year the day-ahead price in seven bidding zones was at or below each price level, averaged over October 2023 to September 2026. Every zone had between about 220 (NO4) and 940 (Spain) hours a year at or below zero, and the Nordic zones had 4,200 to 6,220 hours a year below about €26/MWh. Germany and Denmark have fewer very cheap hours, about 1,140 to 1,260 a year at or below €20/MWh, but highly variable prices.

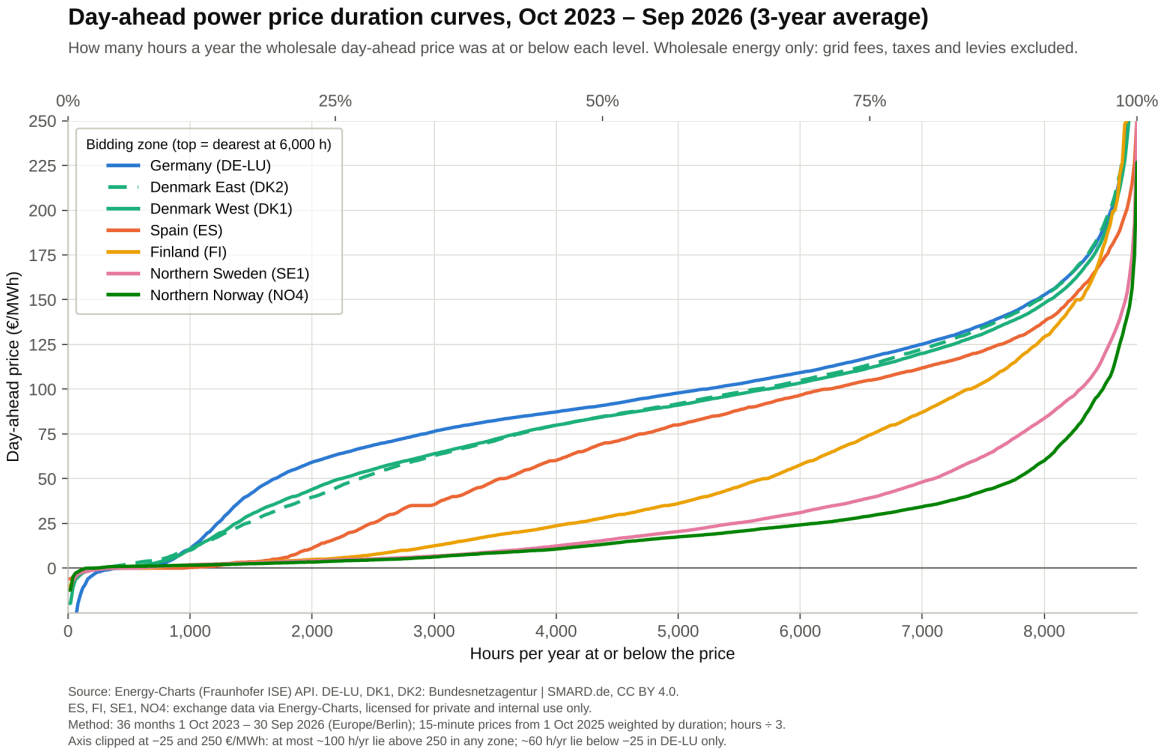

Figure 3. Day-ahead price duration curves, October 2023 to September 2026 (three-year average). Wholesale energy only.

An electrolyser also pays grid fees, taxes and levies, and these differ widely. Germany currently exempts new electrolysers from grid fees for 20 years (§118(6) EnWG, plants commissioned by 4 August 2029), from the KWKG and offshore levies (§25 EnFG, commissioned before 1 January 2030) and from electricity tax, leaving a §19 StromNEV surcharge of €0.50/MWh. Denmark adds Energinet's grid and system tariffs and a small electricity tax, about €16/MWh. Spain and Norway charge partly per kW of capacity, which penalises plants that run few hours. Table 2 gives the resulting average all-in price of the cheapest hours; Figure B1 in Annex B shows the curves.

Table 2. Time-weighted average all-in power price of the cheapest N hours per year (€/MWh)

Bidding zone	1,000 h	2,000 h	4,000 h	6,000 h	8,000 h	Charges at 4,000 h	Hours ≤ €0	Hours ≤ €25.9
Germany (DE-LU)	-4.5	17.5	46.7	63.9	79.8	0.5	640	1,220
Denmark West (DK1)	16.5	30.5	54.9	72.4	88.7	15.9	440	1,380
Spain (ES)	17.8	12.3	25.8	44.7	62.5	6.6	940	2,520
France (FR)	-1.1	6.0	23.6	41.6	58.5	2.2	740	2,300
Finland (FI)	4.1	6.7	12.9	23.3	41.2	6.2	660	4,200
Northern Sweden (SE1)	2.7	2.9	5.0	9.9	19.3	0.8	540	5,540
Northern Norway (NO4)	13.1	4.5	5.6	9.5	16.2	1.6	220	6,220

Day-ahead prices October 2023 to September 2026 (three-year average) plus 2026 grid fees, taxes and levies for a new 100 MW transmission-connected electrolyser, VAT excluded. Hours ≤ €0 and ≤ €25.9/MWh: wholesale price, rounded to 10 h. €25.9/MWh is 0.36 times the average EU ETS allowance price of €72/t over the same period.

Renewable hydrogen rules and cheap hours

Under the EU's rules for renewable fuels of non-biological origin (RFNBOs), Delegated Regulation (EU) 2023/1184, hydrogen made from grid electricity counts as renewable only if the producer meets requirements for additionality (typically a power purchase agreement with new, unsubsidised renewable capacity), temporal correlation and geographic correlation, unless the bidding zone qualifies through a renewable share above 90% or low grid emissions. Temporal correlation is monthly until the end of 2029 and hourly from 2030, and it is deemed met in any hour when the day-ahead price is at or below €20/MWh or below 0.36 times the EU ETS allowance price. The Commission announced a targeted review of these rules in 2026; at the time of writing sbh4 had not seen a final revised text, so investors should check the rules in force.

The low-price provision favours a flexible electrolyser: the hours it prefers to run are often the hours that automatically satisfy the time-matching rule. In Germany only about 1,220 hours per year fell below the €25.9/MWh threshold, against 4,200 to 6,220 hours in Finland, SE1 and NO4.

> **Reading Table 2.**
>
> - Charges matter as much as wholesale prices. At 4,000 h/yr they add €0.5/MWh in Germany, with today's exemptions, but €15.9/MWh in DK1. That is enough to make DK1 dearer than Germany (€54.9 against €46.7/MWh) although its wholesale prices are lower (€39.0 against €46.2/MWh).
> - In Spain and Norway, the average all-in price at 1,000 h/yr is higher than at 2,000 h/yr, because capacity-based charges are spread over fewer hours.
> - The Nordic zones are cheap at almost any utilisation: even at 8,000 h/yr the all-in average is €16/MWh in NO4, €19/MWh in SE1 and €41/MWh in Finland.

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SECTION 5

The cost of firm power

Many hydrogen projects are planned around round-the-clock supply. That is expensive, and a flexible electrolyser does not need it.

To put a price on firmness, sbh4 modelled an off-grid plant that delivers 1 GW in every hour of the year in three regions: western Denmark (west Jutland), northern Germany (Schleswig-Holstein) and Spain (Aragón). Wind and solar capacity were optimised hour by hour for the lowest cost of electricity, with open-cycle gas turbines (OCGTs) filling every gap, using hourly weather and monthly gas and EU ETS prices for October 2023 to September 2026, current technology cost data and a 10% WACC.

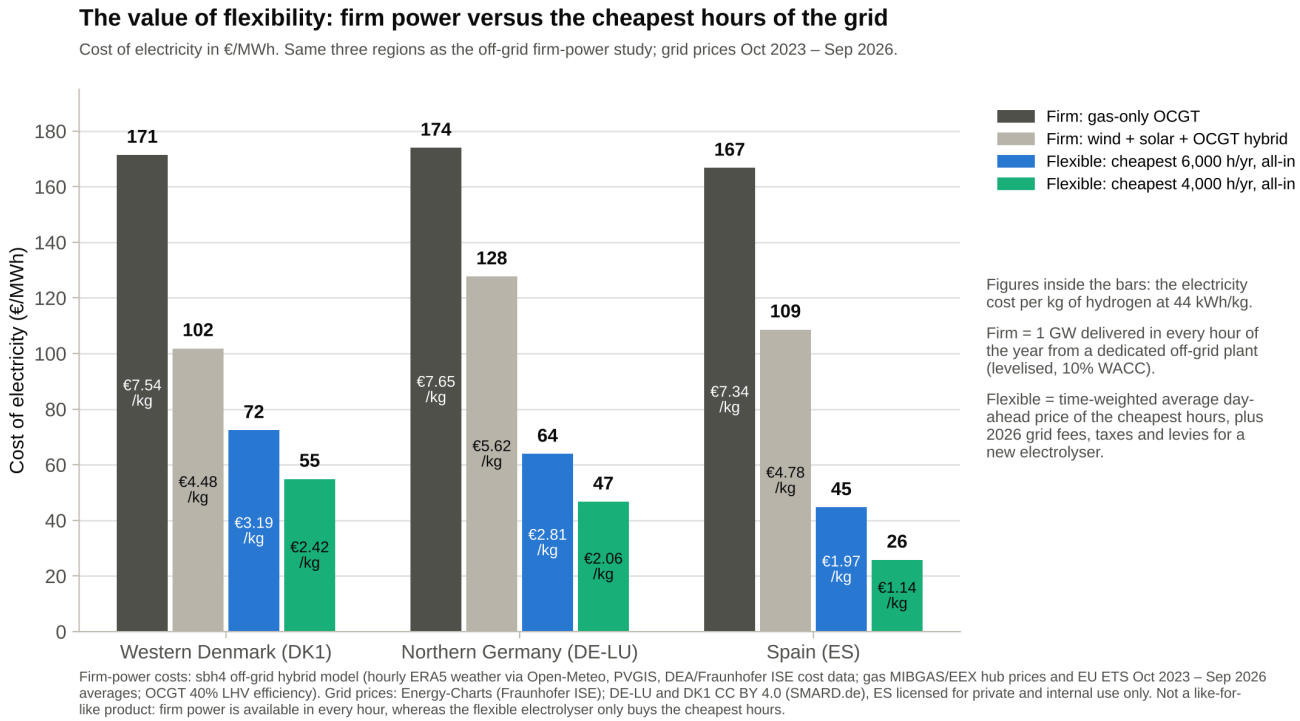


Figure 4. Firm power from dedicated off-grid plants against the average all-in grid price of the cheapest hours. The figures inside the bars convert each electricity cost into € per kg of hydrogen at 44 kWh/kg.

Firm power from the cheapest hybrid configuration costs €102/MWh in western Denmark, €109/MWh in Spain and €128/MWh in northern Germany. Wind and solar supply 65% to 73% of the energy, and the plants still curtail 0.7 to 1.3 TWh/yr of surplus renewable output. Gas-only OCGT supply would cost €167–174/MWh. At 44 kWh/kg, firm hybrid power alone would cost €4.48–5.62 per kg of hydrogen before any capex.

The flexible alternative is far cheaper. The cheapest 4,000 hours of the grid cost €55/MWh all-in in DK1, €47/MWh in Germany and €26/MWh in Spain: €2.42, €2.06 and €1.14 per kg at 44 kWh/kg. The comparison is not like for like, since firm power is available in every hour, but it shows the value of flexibility: about €47 to €83/MWh against firm hybrid supply, or €2.07 to 3.64 per kg of hydrogen.

> **What this means.** An electrolyser that runs flat out on firm power pays for the batteries, gas turbines or overbuilt renewables that make the power firm. A flexible electrolyser instead buys surplus renewable output that would otherwise be curtailed or sold at very low prices, and can earn additional revenue from grid-balancing services. Fast ramping and unlimited starts and stops (18, 26) are therefore commercial, not just technical, attributes.

SECTION 6

LCOH: shiptown versus incumbent technologies

On identical assumptions, shiptown's stated efficiency and its targeted capex make it the lowest-cost option at every combination of power price and operating hours tested.

Table 3. LCOH for hydrogen delivered at 30 bar(g) or more, four electrolyser options (€/kg H_2, 10%/yr capital charge)

System	8,000 h/yr at €60/MWh	4,000 h/yr at €60/MWh	4,000 h/yr at €46.7/MWh (Germany's cheapest 4,000 h)
Siemens Energy Elyzer P-300 (PEM)	4.99	6.73	6.01
thyssenkrupp nucera scalum (AWE)	5.05	6.71	5.96
John Cockerill DQ1000 (pressurised AWE)	4.93	6.53	5.79
shiptown, €1,600/kW	**3.52**	**4.40**	**3.82**

Includes compressor capex, electricity and maintenance for the two atmospheric-pressure systems. shiptown delivers at 35 bar(g) without a compressor. At €1,200/kW, shiptown's LCOH at 8,000 h and €60/MWh would be €3.30/kg.

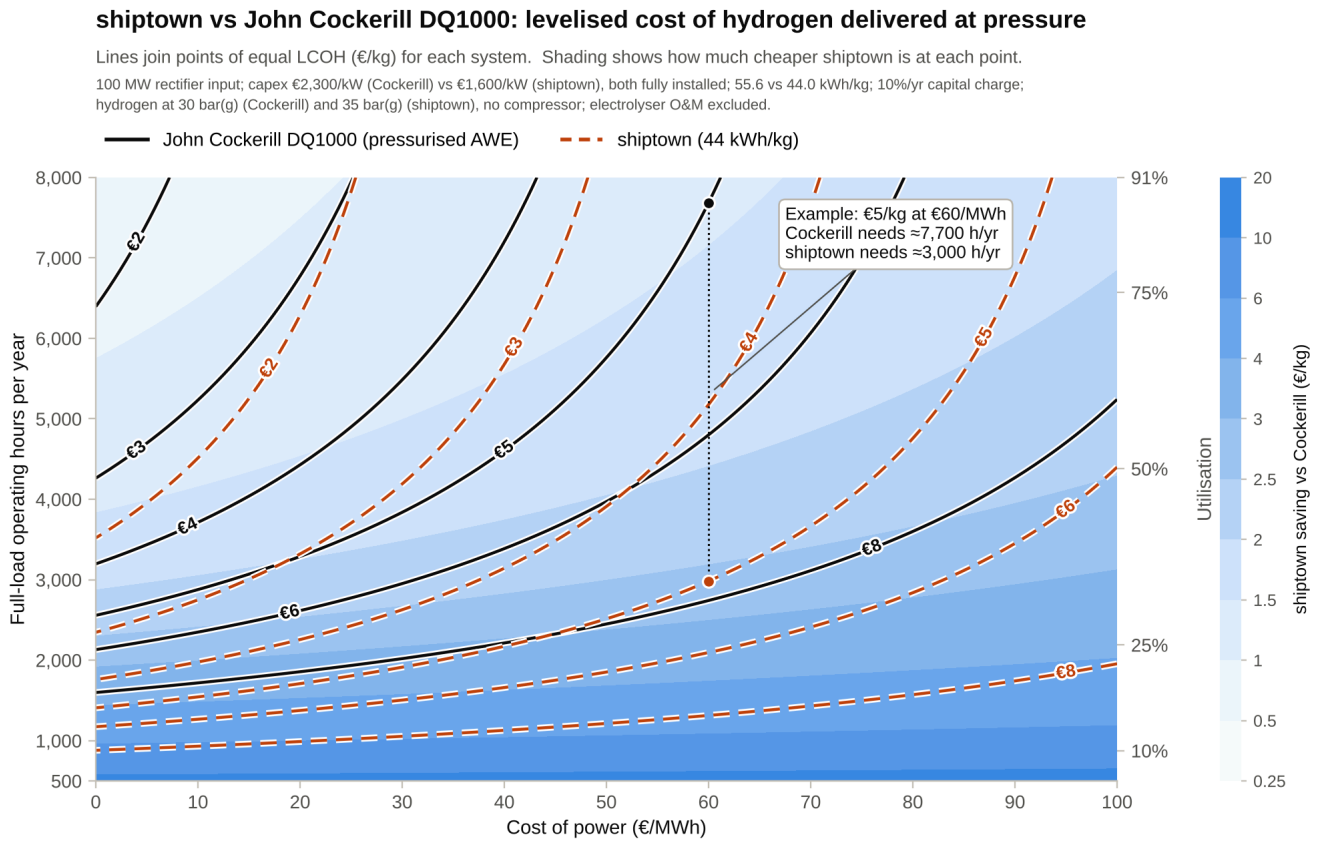


Figure 5. Iso-LCOH lines for shiptown (dashed) and the John Cockerill DQ1000 (solid) across power prices of €0 to €100/MWh and 500 to 8,000 h/yr. The shading shows shiptown's saving. Example: to reach €5/kg at €60/MWh, the DQ1000 must run about 7,700 h/yr; shiptown needs about 3,000 h/yr.

Figure 5 maps the comparison. The saving is smallest, about €0.72 to 1.07/kg, where both plants run close to full time on cheap power (8,000 h/yr at €0 to €30/MWh). It grows quickly at low hours, where capex per kg dominates, and at high power prices, where efficiency dominates. That is the region in which a flexible plant operates in volatile markets.

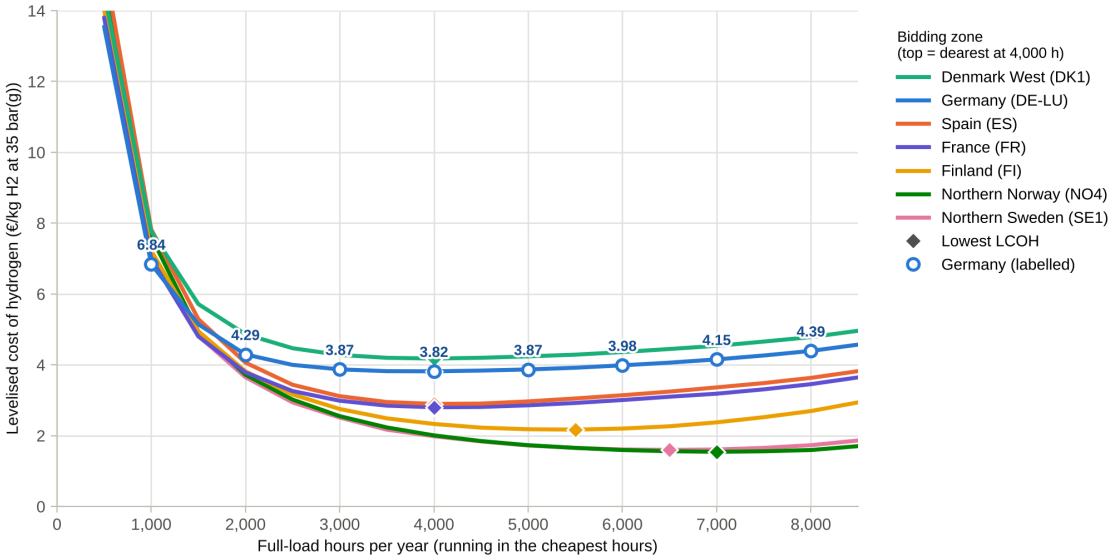
Financing changes the picture. At a 5%/yr capital charge, as might apply to projects with public co-financing or low-cost debt, the DQ1000 needs about 3,800 h/yr to reach €5/kg at €60/MWh and shiptown about 1,500 h/yr (Figure B2 in Annex B). Cheaper capital helps both technologies, and shiptown's saving is at least €0.36/kg everywhere on the map.

SECTION 7

LCOH by country and the company's statements tested

Levelised cost of hydrogen by country: shiptown electrolyser

100 MW rectifier input, capex €1,600/kW (fully installed), 44.0 kWh/kg (75.8% LHV), hydrogen delivered at 35 bar(g) without a compressor, 10%/yr capital charge. Power cost = time-weighted average all-in price of the hours run (day-ahead prices Oct 2023 – Sep 2026 plus 2026 grid fees, taxes and levies with electrolyser exemptions). Points every 500 h; lowest LCOH found on that grid.



Annual average LCOH (€/kg H2)

Hours per year →	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	Lowest (hours)
Germany (DE-LU)	**6.84**	**4.29**	**3.87**	**3.82**	**3.87**	**3.98**	**4.15**	**4.39**	**3.82 (4,000 h)**
Denmark West (DK1)	7.77	4.86	4.28	4.18	4.24	4.36	4.53	4.78	4.18 (4,000 h)
Spain (ES)	7.82	4.06	3.11	2.90	2.97	3.14	3.36	3.63	2.90 (4,000 h)
France (FR)	6.99	3.78	2.98	2.80	2.86	3.00	3.18	3.45	2.80 (4,000 h)
Finland (FI)	7.22	3.81	2.75	2.33	2.18	2.20	2.37	2.69	2.17 (5,500 h)
Northern Sweden (SE1)	7.16	3.65	2.51	1.98	1.72	1.61	1.61	1.73	1.60 (6,500 h)
Northern Norway (NO4)	7.62	3.72	2.55	2.01	1.73	1.59	1.54	1.59	1.54 (7,000 h)

LCOH = capex × capital charge × kWh/kg ÷ hours + average all-in power price × kWh/kg. Excludes electrolyser O&M, stack replacement, degradation, water, H2 drying and storage, grid connection costs and subsidies. Charges per country as in the all-in power cost chart (transmission connection, VAT excluded; Germany assumes the §118(6) EnWG and §25 EnFG exemptions; France assumes the TURPE profile reduction). Values above 14 €/kg are off the chart. Prices: Energy-Charts (Fraunhofer ISE); DE-LU, DK1, FR CC BY 4.0 (SMARD.de); ES, FI, SE1, NO4 licensed for private and internal use only.

Figure 6. shiptown LCOH by bidding zone when the plant runs only in the cheapest hours of each year: fully installed capex €1,600/kW, 44 kWh/kg, hydrogen at 35 bar(g), 10%/yr capital charge, all-in power prices from Table 2.

Table 4. Lowest LCOH by bidding zone and the operating hours at which it occurs (€/kg H_2)

Bidding zone	shiptown €1,600/kW, 10%	shiptown €1,600/kW, 5%	shiptown €1,200/kW, 10%	J. Cockerill DQ1000 €2,300/kW, 10%	shiptown saving, 10%
Germany (DE-LU)	3.82 (4,000 h)	2.53 (2,000 h)	3.28 (3,000 h)	5.66 (5,500 h)	1.84
Denmark West (DK1)	4.18 (4,000 h)	3.06 (2,500 h)	3.69 (3,500 h)	6.13 (5,500 h)	1.95
Spain (ES)	2.90 (4,000 h)	1.94 (3,000 h)	2.45 (3,500 h)	4.53 (5,000 h)	1.63
France (FR)	2.80 (4,000 h)	1.81 (3,000 h)	2.34 (3,500 h)	4.38 (5,000 h)	1.58
Finland (FI)	2.17 (5,500 h)	1.44 (4,500 h)	1.83 (5,000 h)	3.43 (6,000 h)	1.26
Northern Sweden (SE1)	1.60 (6,500 h)	1.01 (5,500 h)	1.32 (6,000 h)	2.59 (7,000 h)	0.99
Northern Norway (NO4)	1.54 (7,000 h)	1.01 (6,000 h)	1.29 (6,500 h)	2.48 (7,500 h)	0.94

Searched in 500 h steps from 500 to 8,500 h/yr. Saving = DQ1000 minimum minus shiptown minimum at €1,600/kW and 10%. At €1,200/kW shiptown's minimum falls to €1.29–3.69/kg; at a 5%/yr capital charge to €1.01–3.06/kg.

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Three patterns

Germany and Denmark: flat and mid-cost. LCOH bottoms out around 4,000 h/yr, at €3.82/kg in Germany and €4.18/kg in DK1, and moves little either side: within 15% and 16% respectively between 2,000 and 8,000 h. Over this range, the falling capital cost per kg and the rising average power price offset each other, so a plant can run more or less as the market dictates.

Spain and France: lower, with a clear optimum. Solar-rich Spain and nuclear- and solar-rich France reach minima of €2.80/kg (France) and €2.90/kg (Spain) at about 4,000 h. LCOH rises faster beyond that, by 35% to 40% across the range.

The Nordic zones: lowest, at high hours. Hydro- and wind-rich SE1 and NO4 reach €1.60 and €1.54/kg at 6,500 to 7,000 h, and Finland €2.17/kg at 5,500 h. Here it pays to run long hours, because even the dearer hours are cheap.

The company's statements tested

Table 5. shiptown's LCOH statements (points 27 to 29, company statement of November 2026) against sbh4's results

Statement	10%/yr capital charge, all-in power (base case)	5%/yr capital charge, all-in power
(27) Very flat LCOH curve for direct grid connection and recent day-ahead prices	**Holds.** Spread from maximum to minimum below 20% from 2,000 to 8,000 h in Germany (15%) and DK1 (16%), 3,000 to 7,000 h in Spain (16%) and France (14%), 4,000 to 7,000 h in Finland (9%), and 5,000 to 8,000 h in SE1 (8%) and NO4 (12%)	**Holds over narrower windows:** Germany 2,000–4,000 h; DK1, Spain and France 2,000–5,000 h; Finland 3,000–6,000 h; SE1 4,000–7,000 h; NO4 4,000–8,000 h
(28) LCOH below €2/kg in the most attractive European bidding zones	**Holds in SE1 and NO4:** SE1 from 4,000 to 8,000 h (lowest €1.60/kg), NO4 from 5,000 to 8,000 h (lowest €1.54/kg). Not reached in Finland (lowest €2.17/kg) or the other zones	**Holds more widely:** SE1 and NO4 2,000–8,000 h; Finland 3,000–7,000 h; France 3,000–4,000 h; Spain at 3,000 h
(29) LCOH below €4/kg in many European locations	**Holds in six of seven zones:** France, Finland, SE1 and NO4 2,000–8,000 h; Spain 3,000–8,000 h; Germany 3,000–6,000 h. Not reached in DK1 (lowest €4.18/kg)	**Holds in all seven zones:** Germany, France, Finland and SE1 1,000–8,000 h; Spain and NO4 2,000–8,000 h; DK1 2,000–6,000 h

shiptown at 44 kWh/kg and €1,600/kW fully installed in all cases; all grid fees, taxes and levies included. Assessed from 1,000 to 8,000 h/yr in 1,000 h steps. Spread = (maximum − minimum) ÷ minimum LCOH over the widest window below 20% that contains the lowest LCOH.

All three statements, as worded in November 2026, hold in the base case: a 10%/yr capital charge with grid fees, taxes and levies. Their scope differs by market. The flat curve holds in every zone, but over windows that range from 3,000 to 6,000 hours wide; the €2/kg threshold is reached only in the two northern zones; and the €4/kg threshold is missed only in DK1, where grid tariffs add about €16/MWh. A lower cost of capital lowers LCOH at every operating level, so the price thresholds are met over equal or wider ranges, but LCOH then rises relatively more steeply at high hours, so the flat windows move to fewer hours, and narrow in Germany, DK1, Spain and France. All results rest on the stated 44 kWh/kg and on the €1,600/kW capex, which remain the first items to evidence (Section 10).

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SECTION 8

Investment case: 100 MW in Germany at €7/kg

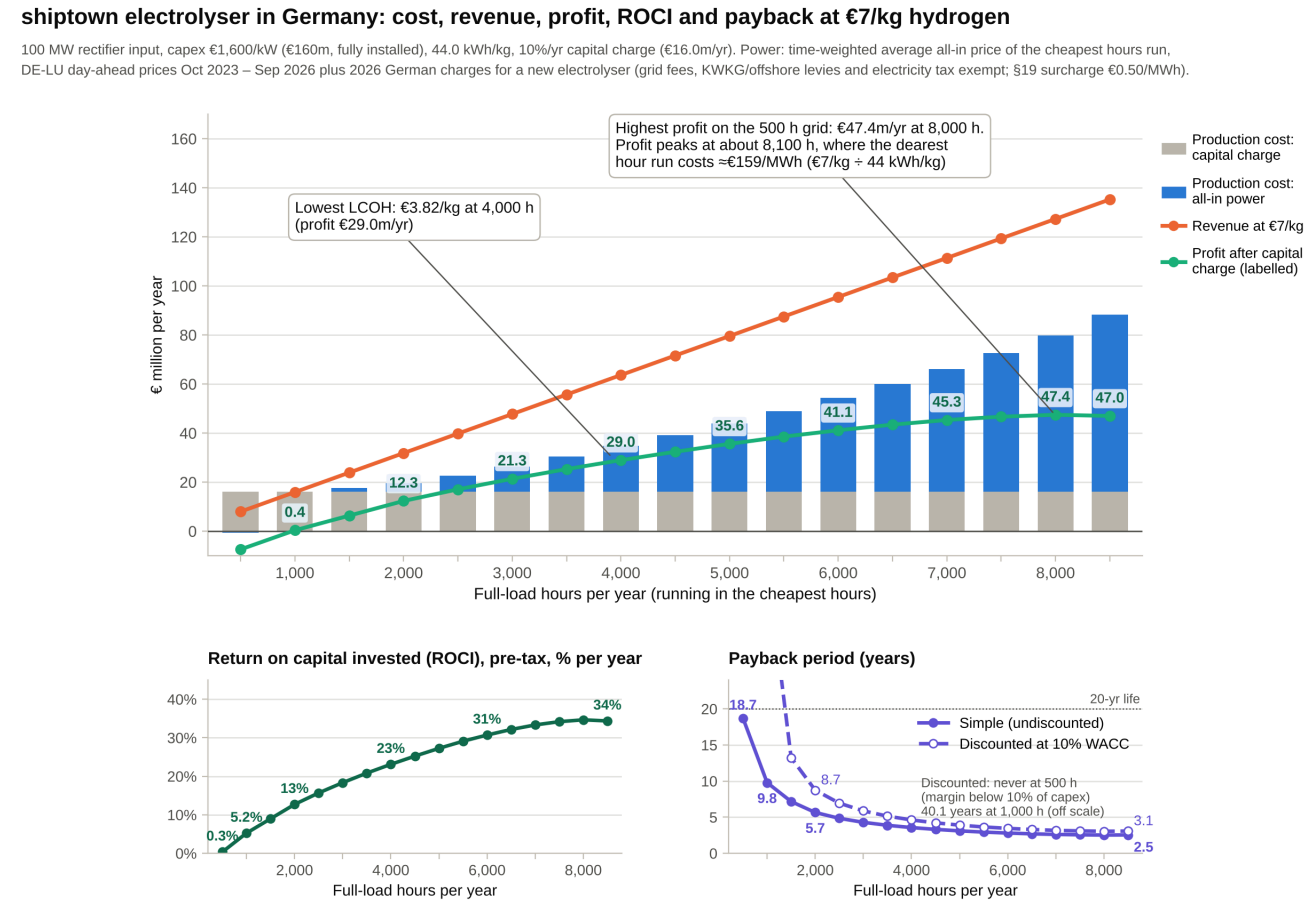

Figure 7. A 100 MW shiptown plant in Germany selling hydrogen at €7/kg: production cost, revenue, profit after a 10% capital charge, pre-tax return on capital invested (ROCI) and payback, by annual operating hours.

Table 6. Germany at €7/kg by annual operating hours

Hours per year	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000
Hydrogen output (t/yr)	2,273	4,545	6,818	9,091	11,364	13,636	15,909	18,182
Average all-in power price (€/MWh)	-4.5	17.5	34.6	46.7	55.9	63.9	71.5	79.8
LCOH (€/kg)	6.84	4.29	3.87	3.82	3.87	3.98	4.15	4.39
Revenue at €7/kg (€m/yr)	15.9	31.8	47.7	63.6	79.5	95.5	111.4	127.3
Profit after capital charge (€m/yr)	0.4	12.3	21.3	29.0	35.6	41.1	45.3	47.4
ROCI, pre-tax	5.2%	12.7%	18.3%	23.1%	27.2%	30.7%	33.3%	34.6%
Simple payback (years)	9.8	5.7	4.3	3.6	3.1	2.8	2.6	2.5
Discounted payback at 10% (years)	40.1	8.7	5.9	4.6	3.9	3.4	3.2	3.0

Discounted payback at 1,000 h exceeds the 20-year life assumed for depreciation. Profit = revenue − power cost − €16m/yr capital charge.

With Denmark, Germany is the dearest of the seven markets analysed for producing hydrogen, but it has large, policy-backed demand. It is therefore a useful stress test.

The plant costs €160m at €1,600/kW, fully installed. At 4,000 h/yr it produces 9,091 t of hydrogen at an LCOH of €3.82/kg. Sold at an assumed €7/kg, it earns €63.6m of revenue, an operating margin of €45.0m and a profit of €29.0m/yr after the 10% capital charge: a pre-tax ROCI of 23% and a simple payback of 3.6 years (4.6 years discounted at 10%).

Profit keeps rising with operating hours, because every hour whose all-in price is below €7/kg ÷ 44 kWh/kg ≈ €159/MWh adds margin. Profit therefore peaks at about 8,100 h/yr; on the 500 h grid used here the highest profit is €47.4m/yr at 8,000 h (ROCI 34.6%). The lowest LCOH and the highest profit are therefore reached at different operating points.

Table 7. Sensitivity to the hydrogen sales price, 100 MW in Germany

H_2 price	Profit 4,000 h, €m/yr	ROCI 4,000 h	Payback 4,000 h, yrs	Most profitable hours (500 h grid)	Profit there €m/yr	ROCI there	Break-even power price
€5/kg	10.8	11.7%	6.0	6,500	13.9	13.7%	€114
€6/kg	19.9	17.4%	4.5	7,500	29.6	23.5%	€136
€7/kg	29.0	23.1%	3.6	8,000	47.4	34.6%	€159
€8/kg	38.0	28.8%	3.0	8,500	66.3	46.4%	€182

Profit after a 10%/yr capital charge (€16m/yr). ROCI = (revenue − power cost − €8m/yr depreciation) ÷ €160m. Break-even power price = H_2 price ÷ 44 kWh/kg: the plant should run every hour below it.

What could reduce these returns

- **Costs not in the model.** Electrolyser O&M, stack replacement, water, storage and corporate tax are excluded. Each 1% of capex per year in fixed O&M costs €1.6m/yr, or €0.18/kg at 4,000 h/yr. A 10% WACC over 20 years implies an 11.75% capital charge rather than 10%, which lowers profit by €2.8m/yr.
- **Grid charges after 2029.** The German grid-fee and levy exemptions apply to plants commissioned by August and December 2029 respectively; according to a draft determination by the Federal Network Agency (April 2026), the grid-fee exemption may also require a final investment decision before 2027. shiptown targets 100 MW projects from 2030. Each €10/MWh of additional charges adds €0.44/kg. With €20/MWh, profit at 4,000 h falls to €21.0m/yr (ROCI 18%).
- **Price risk.** Results use October 2023 to September 2026 prices with perfect foresight. More renewables would likely deepen the cheap hours, but more flexible demand, batteries and interconnection would compete for them.
- **Offtake.** €7/kg is an illustrative price, not a forecast. Quota-driven demand in transport and industry and RFNBO certification will determine what buyers pay; the price risk is reduced by long-term contracts.

> **Reading the numbers.** These are project-level returns for a plant built with mature shiptown equipment. They show why the technology is worth developing; they are not the returns available to an investor in shiptown today, which depend on the company reaching that maturity.

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SECTION 9

shiptown: strategy, roadmap and team

shiptown A/S is a Danish company in Fredericia developing a paradigm-shifting electrolyser and reversible hydrogen technology. Its stated vision is ‘a future where renewable energy is available whenever we need it’.

Products and business model

One technology platform supports two products. **H-Lyzer** is the electrolysis-only product analysed in this paper. **H-Battery** uses the same stack for electrolysis and fuel-cell operation to store electricity as hydrogen for hours to days; shiptown reports reversible operation verified and a round-trip efficiency of about 50% on current results. The business model has three revenue streams: system sales; service and maintenance agreements; and engineering support for project integration. Market entry starts with an H-Lyzer demonstration at European Energy’s existing site in Denmark, presented in October 2026 as a first 2 MW demonstration.

Progress to date

shiptown reports five-cell stack validation, 90% system efficiency (HHV basis) measured, pressure testing above 35 bar, reversible operation verified, more than 20 patent applications with five PCT filings, and about €3.2m of funding secured from equity, grants and a loan. It works with research partners Aalborg University, DTU and FORCE Technology; product sponsor Siemens; European Energy as strategic partner, investor and board member; and an industry and manufacturing network of init, ECM Industries, AMES, AE Partner and European Energy.

Table 8. Roadmap as stated in shiptown’s company statement (November 2026)

Timing	Milestone	Point
Today	TRL 4 completed; equipment being built to complete TRL 5. Validation of critical component designs and manufacturing tolerances; screening of manufacturing partners. Stack and module assembly line designed, sized and costed.	35, 36, 37
2027	€6 million capital raise for materials optimisation, cell validation, partner screening, stack building and bankability-grade testing of pre-production stacks to a locked-down design.	45
Mid-2028	TRL 6 completed at a confirmed test site, with construction partners and grant funding secured for the consortium.	38
End of decade	€18–20 million capital raise for scaled component production, system assembly and full go-to-market execution.	46
From 2030	Bankable equipment able to support 100 MW projects reaching commercial operation.	34

Company statements. The roadmap depends on the financing in points 45 and 46.

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Figure 8. Test work in shiptown's workshop (photo: shiptown A/S investor presentation, October 2026).

Team and governance

Name	Role	Background
Marie Vedel Lauridsen	Co-founder and CEO	Formerly Ørsted and Energy Cluster Denmark
Karsten Schibsbye	Founder and CTO	Formerly Stiesdal, Green Hydrogen Systems and Siemens
Javier Bermudez Blanco	Industrial PhD, chemical engineering	Aalborg University
Jørgen Vig	Mechanical development and construction	
Klaus Andersen	Prototype and testing	
Bertram Jørgensen	Marine engineering student	
Eva Ravn Nielsen	Chair of the Board	Head of Advisory, Rambøll
Knud Erik Andersen	Board member and investor	CEO, European Energy
Lars Fejer	Investor and advisor	Owner, LF Green Capital
Rene Alcaraz Frederiksen	Market advisor	VP Power-to-X, European Energy
Stephen B. Harrison	Strategic advisor	sbh4 consulting; author of this paper

Source: shiptown investor presentation, October 2026.

The combination of a hands-on engineering team with a strategic investor that is also a renewable project developer and a likely first customer is a strength: European Energy can host demonstrations, provide operating data and offer a route to market. It also concentrates risk; investors should understand the terms of that relationship and how shiptown will win customers beyond it.

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SECTION 10

What investors should test

The economic analysis shows a large prize if the technology performs as stated. The diligence questions below would turn the company statements into bankable evidence.

Topic	Why it matters	Evidence to request
System efficiency	LCOH is proportional to kWh/kg; 44 kWh/kg is the core of the value proposition.	Module-scale test data on a site-boundary basis (rectifier, gas treatment, heat rejection, controls, standby) at several loads and temperatures; third-party witness.
Durability	Stack replacement is excluded here; frequent cycling is central to the business case.	Degradation rate in µV/h or %/1,000 h under daily start-stop cycling; stack life and warranty terms (30).
Scale-up	Efficiency and gas purity measured on five cells may not carry over to full-size stacks and modules.	Results from the 6 kW stack, the planned 75 kW stack and the demonstration; current density and cell area at each step.
Capex	This paper uses €1,600/kW fully installed, shiptown's target based on its costed bill of materials (5, 6).	Bill of materials and assembly-line costing (37); installation-cost basis for typical European sites; scope split between stack, balance of plant, power electronics and installation.
Pressure and purity	Delivery at 35 bar(g) from a PN63 design avoids a compressor for many users; purity drives drying cost.	Delivery pressure at full and part load; PN63 design basis and pressure-equipment certification; H_2-in-O_2 and O_2-in-H_2 at low load; need for a dryer to reach ISO 14687 grades.
Safety and certification	Bankability requires CE marking, hazard studies and insurer acceptance.	Evidence for gas separation (10, 14); HAZOP, ATEX classification, CE route and timing.
Market and regulation	Returns depend on hydrogen prices, grid charges and RFNBO rules.	Offtake strategy; treatment of grid fees after the German exemptions expire; RFNBO compliance route for each target market.
Company	Execution depends on financing, people and partners.	Funding runway to TRL 6; key-person cover; IP status of the 20+ applications; terms of the European Energy relationship.

> **Order of priority.** System efficiency and durability first, because they determine whether the economics in this paper apply at all. Capex second, because the €1,600/kW carries most of the saving at low operating hours. Market and regulatory risks matter, but they apply equally to every electrolyser technology.

SECTION 11

Limitations

1. **Company data.** shiptown's efficiency, purity, pressure, flexibility and durability figures are company statements. sbh4 has not witnessed tests. The €1,600/kW capex is shiptown's target, based on its costed bill of materials, and has not been independently verified.
2. **Scope of LCOH.** Capital charge and electricity only, plus compression where needed. Electrolyser O&M, stack replacement, degradation, water, drying, storage, grid connection, land, offtake logistics, subsidies and tax are excluded.
3. **Capital charge.** A flat annual charge of 10% (or 5%) of capex stands in for a full financial model; 10%/yr is close to the capital recovery factor at 8% over 20 years.
4. **Perfect foresight.** The plant is assumed to run in exactly the cheapest hours of each year, at full load, with no minimum run time. Real dispatch would capture somewhat less of the price spread.
5. **Historic prices.** October 2023 to September 2026 includes the end of the 2022–2023 price shock. Future prices will differ, and large flexible loads would themselves raise the price of the cheapest hours.
6. **Grid charges.** 2026 tariffs and current exemptions; transmission connection assumed; regional charges, connection costs and some ancillary charges excluded. Danish tariffs are the published consumer rates.
7. **Firm-power model.** Three years of hourly weather with yields calibrated to long-term references; cost-optimised hybrid design with OCGT back-up; no storage, transmission or market sales of surplus power.
8. **Benchmarks.** Vendor datasheet efficiencies at beginning of life; fully installed capex values for the commercial systems are sbh4 estimates and vary widely between projects.

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ANNEX A

shiptown's 46 points: evidence register

Points paraphrased from shiptown's company statement of November 2026. Status: Company statement not verified by sbh4; Partly supported by evidence in shiptown's October 2026 investor presentation; Tested here with sbh4's models; Forward-looking plan or expectation.

#	Point	Theme	Status	Note
1	44 kWh/kg H_2 at 35 bar(g), >99.9% purity, at the site boundary	Efficiency	Partly supported	Five-cell stack measured at 90% system efficiency (HHV, ≈43.8 kWh/kg); module-scale figure not yet demonstrated
2	Efficiency comparable to published water-fed SOEC values, with hydrogen at pressure, a more robust design and better manufacturability	Efficiency	Company statement	
3	Efficiency comparable to published values of one or two other start-ups with innovative electrolysers, with delivery at 35 bar(g) and a system designed to PN63	Efficiency	Company statement	
4	High European content in components and assembly, to meet IAA procurement requirements and maximise EU support	Cost and supply	Forward-looking	
5	Bill of materials for cell, stack and system complete and costed	Cost and supply	Company statement	Basis of the €1,600/kW used in this paper
6	Equipment capex equal to or below the lowest-cost available technologies; fully installed capex of €1,600/kW targeted	Cost and supply	Company statement	Base case in this paper
7	Total water consumption at or below state of the art; no cooling water	Materials and water	Company statement	
8	Suitable for hot, humid sites: no cooling water	Materials and water	Company statement	
9	No gas compression or interstage cooling water needed to supply hydrogen at pressure	System design	Partly supported	Pressure testing >35 bar reported
10	Oxygen and hydrogen produced at separate locations, with three layers of the cell between them	Architecture and safety	Company statement	
11	Ceramic-type insulation between electrodes enables higher temperatures than polymer membranes or diaphragms	Architecture and safety	Company statement	
12	Higher temperature than state-of-the-art alkaline gives very high electrolyte conductivity	Efficiency	Company statement	
13	No external heat needed during ramp-up or operation	Efficiency	Company statement	Consistent with operation above the thermoneutral energy (39.4 kWh/kg)
14	Intrinsically safe, with several physical mechanisms preventing gas mixing	Architecture and safety	Company statement	
15	No PGMs in any component	Materials and water	Company statement	Also stated in the October 2026 presentation
16	No PFAS in any component, including gas-tight seals	Materials and water	Company statement	Also stated in the October 2026 presentation
17	Commonly available materials and industrial manufacturing processes	Materials and water	Company statement	
18	Unlimited starts and stops per day and year; no large BESS needed	Flexibility	Company statement	
19	Warm standby below 5% of nominal power	Flexibility	Company statement	
20	Negligible cold-standby power: control and safety systems only	Flexibility	Company statement	
21	Alkaline electrolyte at a pH that permits common steel grades	Materials and water	Company statement	
22	High efficiency without catalysts; catalysts a possible future improvement	Efficiency	Company statement	

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#	Point	Theme	Status	Note
23	Simple zero-gap cell, electrode in direct contact with the bipolar plate, minimises ohmic losses	Efficiency	Company statement	
24	Operating temperature below 120 °C, allowing common steel grades	Materials and water	Company statement	
25	High tolerance of instantaneous power loss, for grid services and EU shut-off rules	Architecture and safety	Company statement	
26	Full ramp up or down of electrical input in under 10 s; gas output lags by tens of seconds to minutes	Flexibility	Company statement	
27	Very flat LCOH curve for direct grid connection and recent day-ahead prices	Economics	Tested here	Holds in the base case in all seven zones (Table 5)
28	LCOH below €2/kg in the most attractive European bidding zones	Economics	Tested here	Holds in SE1 and NO4 (Table 5)
29	LCOH below €4/kg in many European locations	Economics	Tested here	Holds in six of seven zones (Table 5)
30	No noticeable degradation under flexible operation and frequent shutdowns	Architecture and safety	Company statement	Long-duration data needed
31	Cell and stack unlike any other electrolyser on the market	Architecture and safety	Company statement	
32	Very compact, with minimal balance of plant	System design	Company statement	
33	40 stacks per 20-foot container; single stacks ‘hot-swappable’ while the module operates	System design	Company statement	Module render in the October 2026 presentation
34	Bankable equipment for 100 MW projects with COD from 2030	Maturity and roadmap	Forward-looking	
35	TRL 4 completed; building equipment to complete TRL 5	Maturity and roadmap	Company statement	
36	Validating component design and tolerances; screening manufacturing partners	Maturity and roadmap	Company statement	
37	Stack and module assembly line designed, sized and costed	Cost and supply	Company statement	
38	TRL 6 in mid-2028; test site, construction partners and consortium grant funding secured	Maturity and roadmap	Forward-looking	
39	Proprietary technology protected by multiple patents	Maturity and roadmap	Partly supported	October 2026 presentation: 20+ patent applications, 5 PCT filings
40	Principles applicable to a fuel cell of similar architecture	Platform	Forward-looking	Reversible H-Battery in development; not assessed
41	Uncomplicated board structure, rapid decisions	Organisation	Company statement	
42	Led and staffed by people with decades of industrial experience	Organisation	Partly supported	Consistent with team backgrounds in the presentation
43	Backed by European Energy as investor and strategic partner	Organisation	Partly supported	Presentation: investor, board seat and demonstration host
44	Advisors and board with Stiesdal, Green Hydrogen Systems, Ørsted, European Energy, Rambøll, Linde and sbh4 experience	Organisation	Partly supported	Consistent with the presentation; sbh4 is the author of this paper
45	€6 million capital raise in 2027 for validation, stack build and bankability testing	Financing	Forward-looking	
46	€18–20 million capital raise at the end of the decade for scale-up and go-to-market	Financing	Forward-looking	

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ANNEX B

Methodology

B1 Levelised cost of hydrogen

For a plant with fully installed capex C (€/kW of rectifier AC input), annual capital charge r, specific energy consumption e (kWh/kg) and N full-load hours per year:

$$\text{LCOH} = C \times r \times e \div N + \bar{p}(N) \times e \div 1{,}000$$

where $\bar{p}(N)$ is the time-weighted average all-in power price of the N cheapest hours (€/MWh). shiptown is modelled at e = 44 kWh/kg with hydrogen delivered at 35 bar(g) without a compressor. Atmospheric-pressure systems add a four-stage intercooled compressor to 31 bar(a): suction 40 °C, 75% isentropic and 95% motor efficiency, €3,000/kW installed and 5%/yr maintenance. Results are on an LHV basis (33.33 kWh/kg).

B2 Power prices

Day-ahead prices for 1 October 2023 to 30 September 2026 were taken from Energy-Charts (Fraunhofer ISE); 15-minute prices from 1 October 2025 are weighted by duration. For each zone the time-weighted average price of the cheapest N hours per year is computed exactly from these data. The plant is assumed to know prices in advance and to run at full load in those hours.

B3 Grid fees, taxes and levies (2026)

Zone	Charges applied	At 4,000 h €/MWh
Germany (DE-LU)	§19 StromNEV surcharge €0.50/MWh. Grid fees (§118(6) EnWG), KWKG and offshore levies (§25 EnFG) and electricity tax (§9a StromStG) exempt for qualifying electrolysers.	0.5
Denmark (DK1)	Energinet grid and system tariffs (11.5 øre/kWh) plus electricity tax after refund (0.4 øre/kWh).	15.9
Spain (ES)	6.4TD access tolls and charges (energy and capacity terms) plus electricity tax on a reduced base (minimum €0.5/MWh).	6.6
France (FR)	TURPE 7 HTB2 with the electro-intensive profile abatement; excise exempt for electrolysis.	2.2
Finland (FI)	Fingrid consumption and output fees plus electricity tax class II and strategic stockpile fee.	6.2
Sweden (SE1)	Svenska kraftnät power fee (33 SEK/kW/yr), energy fee net of loss credit, energy tax.	0.8
Norway (NO4)	Statnett fixed term for large consumers (67.5 NOK/kW/yr above 100 GWh/yr).	1.6

B4 Firm-power model

Hourly wind and solar output at each site from ERA5 reanalysis (via Open-Meteo) for October 2023 to September 2026, with annual yields calibrated to long-term references (Danish Energy Agency and German reference yields for wind; PVGIS-SARAH3 for solar). Wind and single-axis tracking PV capacities were optimised to minimise the total cost of delivering 1 GW in every hour, with OCGTs (€850/kW, 40% LHV efficiency, 25-year life) covering every shortfall. Wind and PV costs from the Danish Energy Agency technology data, Fraunhofer ISE and market surveys; gas at monthly hub prices plus €1.5/MWh delivery (€41–43/MWh on average); EU ETS at monthly prices (about €72/t on average), all for October 2023 to September 2026; 10% WACC.

B5 Investment metrics

Profit = revenue − power cost − 10% capital charge. Operating margin = revenue − power cost. ROCI = (operating margin − straight-line depreciation over 20 years) ÷ capex. Simple payback = capex ÷ operating margin. Discounted payback = years until the operating margin, discounted at 10%, repays capex. All pre-tax, with capex at year 0 and full output from year 1.

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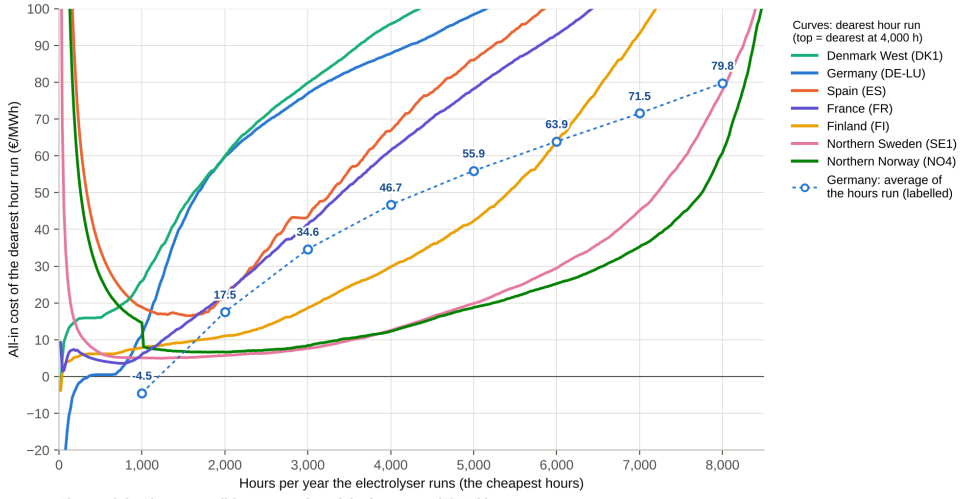
All-in power cost for a new 100 MW electrolyser, up to €100/MWh

Day-ahead prices Oct 2023 – Sep 2026 (3-year average) plus 2026 grid fees, electricity taxes and levies (VAT excluded), with electrolyser exemptions where they apply.
Curves: cost of the dearest hour the plant runs. Table: average cost over all the hours it runs. Capacity charges are spread over the hours run.



Time-weighted average all-in power price of the hours run (€/MWh)

Hours per year →	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000
Germany (DE-LU)	**-4.5**	**17.5**	**34.6**	**46.7**	**55.9**	**63.9**	**71.5**	**79.8**
Denmark West (DK1)	16.5	30.5	43.9	54.9	64.3	72.4	80.2	88.7
Spain (ES)	17.8	12.3	17.4	25.8	35.4	44.7	53.5	62.5
France (FR)	-1.1	6.0	14.5	23.6	32.9	41.6	49.5	58.5
Finland (FI)	4.1	6.7	9.2	12.9	17.5	23.3	31.1	41.2
Northern Sweden (SE1)	2.7	2.9	3.7	5.0	7.1	9.9	13.7	19.3
Northern Norway (NO4)	13.1	4.5	4.6	5.6	7.3	9.5	12.2	16.2

Assumptions (transmission connection, 2026 rates): DE-LU grid fees, KWKG/offshore levies and electricity tax exempt for green-hydrogen electrolysers commissioned by Aug 2029; §19 StromNEV surcharge €0.50/MWh. DK1: Energinet 11.5 øre/kWh + elafgift 0.4 øre/kWh. ES: 6.4TD peajes + cargos (€2.2/MWh + €15.8/kW/yr) + electricity tax on 15% of base. FR: TURPE 7 HTB2, cheapest of CU/MU/LU at Aug-2026 levels, 74% profile abatement (81% from 7,000 h), CTA 10.11% on fixed part; accise exempt for electrolysis. FI: Fingrid fees €4.8/MWh + tax class II €1.35/MWh. SE1: SvK power fee 33 SEK/kW/yr, 8% loss credit, tax 0.6 öre/kWh. NO4: Statnett 67.5 NOK/kW/yr (135 below 100 GWh/yr); loss credit not included. Excludes regional/distribution charges, connection costs, Spain's ancillary-service costs and capacity-mechanism costs. Prices: Energy-Charts (Fraunhofer ISE); DE-LU, DK1, FR CC BY 4.0 (SMARD.de); ES, FI, SE1, NO4 private and internal use only.

Figure B1. All-in power cost for a new 100 MW electrolyser: cost of the dearest hour run (curves) and average of the hours run (table).

shiptown vs John Cockerill DQ1000: levelised cost of hydrogen delivered at pressure

Lines join points of equal LCOH (€/kg) for each system. Shading shows how much cheaper shiptown is at each point.

100 MW rectifier input; capex €2,300/kW (Cockerill) vs €1,600/kW (shiptown), both fully installed; 55.6 vs 44.0 kWh/kg; 5%/yr capital charge; hydrogen at 30 bar(g) (Cockerill) and 35 bar(g) (shiptown), no compressor; electrolyser O&M excluded.

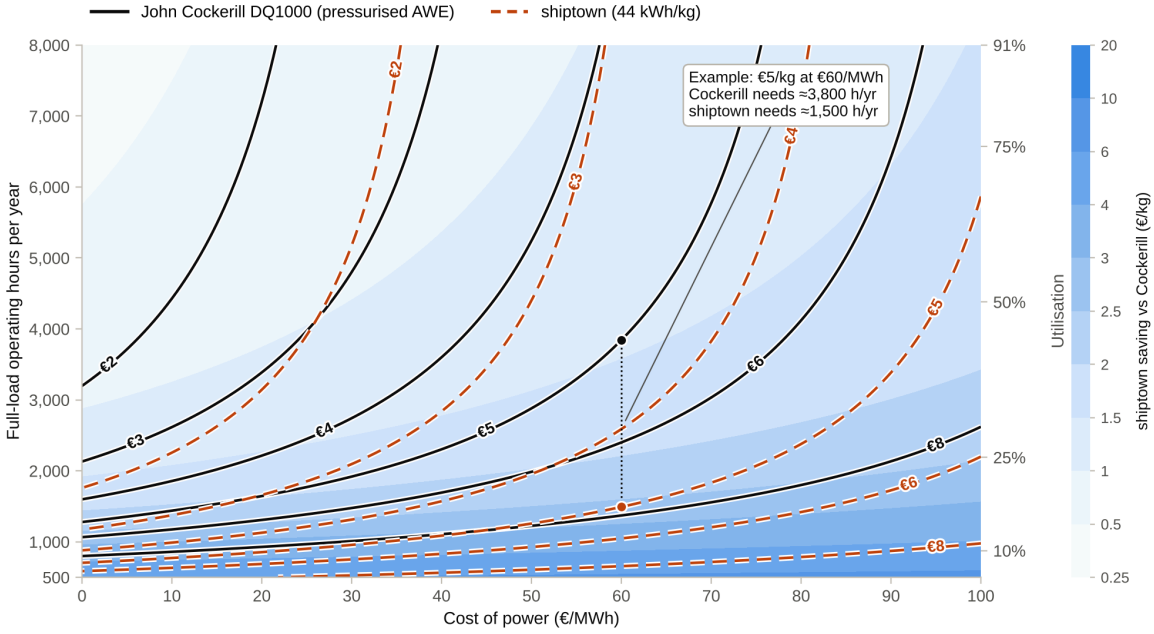


Figure B2. As Figure 5, with a 5%/yr capital charge for both systems.

ANNEX C

Assumptions register

Block	Parameter	Value	Basis	Sensitivity
shiptown	Specific energy consumption	44.0 kWh/kg	shiptown company statement (1)	High
shiptown	Installed capex	€1,600/kW fully installed (€1,200/kW sensitivity)	shiptown target based on its costed bill of materials (5, 6)	High
shiptown	Delivery pressure	35 bar(g), no compressor; PN63 design	shiptown company statement (1, 3)	Low
Benchmarks	Siemens Energy Elyzer P-300	52.2 kWh/kg, €2,500/kW, 1.05 bar(a)	Vendor data; sbh4 capex estimate, fully installed	Medium
Benchmarks	thyssenkrupp nucera scalum	54.5 kWh/kg, €2,300/kW, 1.3 bar(a)	Vendor data; sbh4 capex estimate, fully installed	Medium
Benchmarks	John Cockerill DQ1000	55.6 kWh/kg, €2,300/kW, 31 bar(a)	Vendor data; sbh4 capex estimate, fully installed	Medium
Finance	Annual capital charge	10% of capex (5% sensitivity)	≈ CRF at 8% over 20 years	High
Finance	Plant size	100 MW rectifier AC input	Reference plant	Low
Power	Price data	Day-ahead, Oct 2023 – Sep 2026	Energy-Charts (Fraunhofer ISE)	High
Power	Dispatch	Cheapest N hours, perfect foresight	sbh4	Medium
Power	Grid fees, taxes, levies	2026 rates, current exemptions (Annex B3)	TSO and regulator tariffs	Medium
Compression	Compressor	4 stages, 75% isentropic, €3,000/kW, 5%/yr maintenance	Literature and vendor data	Low
Germany case	Hydrogen price	€7/kg (€5–8/kg sensitivity)	Illustrative	High
Germany case	Depreciation	20 years straight line	sbh4	Low
Firm power	WACC and backup	10%; OCGT €850/kW, 40% LHV	DEA technology data; sbh4	Medium

Sensitivity: effect on the headline LCOH and returns. LCOH is proportional to specific energy consumption, so ±10% kWh/kg moves LCOH by ±10%.

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ANNEX D

References and disclaimer

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Disclaimer. This white paper is a techno-economic review compiled from company information and public data under the assumptions set out above. It is not investment, legal or tax advice, an offer of securities or a recommendation to invest in shiptown A/S or any project. Company statements have not been independently verified. Forward-looking statements depend on technical, commercial and regulatory developments that may not occur. Readers should carry out their own due diligence before any investment decision.

Disclosure. Stephen B. Harrison of sbh4 consulting is Strategic Advisor to shiptown A/S. [To complete before release: nature of any remuneration, options or shareholding.]

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Stephen B. Harrison is the founder and managing director of sbh4 GmbH in Germany. His work focuses on decarbonisation and the reduction of greenhouse-gas (GHG) emissions. E-fuels, bio-fuels, hydrogen, ammonia, long-duration energy storage (LDES) and CCU/S are the fundamental pillars of his consulting.

Stephen has extensive investment due-diligence advisory experience in the energy and clean-tech sectors. Private equity firms, investment fund managers and green-tech start-ups are regular clients. He also supports operating companies in their mission to decarbonise their scope 1, 2 and 3 GHG emissions, and helps start-ups scale up successfully through development plans aligned to market needs.

In 2023, Stephen evaluated seven CCTUS, hydrogen and e-fuels submissions to the European Commission's Third Innovation Fund. In 2025 he assessed seven Innovation Fund applications for e- and bio-methanol production and, in 2026, six large-scale bio-SAF and e-SAF projects. In each of these years the fund allocated more than €2 billion to large-scale decarbonisation projects in Europe. In 2024, 2025 and 2026 he also supported the European Commission with venture-capital investment due diligence, and assessed 15 Horizon grant applications and more than 30 Marie Curie Post Doctoral Network and Doctoral Fellowship applications.

Stephen has served as international expert and team leader for three Asian Development Bank (ADB) projects related to CCU/S and renewable hydrogen deployment in Pakistan, Palau and Viet Nam. He has also supported the IFC and the World Bank on e-fuels and green hydrogen strategy development projects in Namibia and Pakistan, and on project evaluations in Paraguay and India.

With a background in industrial and specialty gases, including 27 years at BOC Gases, The BOC Group and Linde Gas, Stephen has intimate knowledge of e-fuels, hydrogen, ammonia and carbon dioxide from commercial, technical and operational perspectives. For 14 years he was a global business leader in these FTSE 100 and DAX 30 companies.

As a member of the H2 View (2020–26) and gasworld (2018 to present) editorial advisory boards, Stephen has advised the direction of leading hydrogen-focused international publications for more than six years. Through H2 View, World Hydrogen Leaders and Sustainable Aviation Futures he has led masterclasses on hydrogen, SAF and hydrogen derivatives in virtual and live sessions. He chaired the e-fuels and hydrogen propulsion track at the Hydrogen Technology Exhibition in 2023 and 2024, and has supported the event as an Advisory Board member since early 2025.

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