Supplementary Material

# Overview of Power-to-X projects

Table 1 Power-to-X pilot and demonstration projects in Europe since 2000

| **Acronym/ location/ name of the project** | **Type of Electrolyzer** | **Capacity kW** | **Commis- sioning** | **Processing H2** | **Country** | **Electricity source** | **CO2 source** | **Source**  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Blending into the natural gas grid** |  |  |  |  |  |  |  |  |
| Ameland | PEM | 8.3 | 2008f | - | The Netherlands | PV | - | (Kippers et al., 2011) |
| Hybrid power plant Prenzlaua | Alkaline | 500 | 2011 | - | Germany | Wind | - | (Fischer et al., 2016) |
| Morbach | Alkaline | 25 | 2011f | cat. Methanation | Germany | Wind, PV | Biogas | (Energielandschaft Morbach, 2015) |
| H2-Researchcentre BTU | Alkaline | 145 | 2012 | - | Germany | n.s. | - | (dena, 2012a) |
| Methanation at Eichhof |  |  |  |  |  | n.s. | Biogas |  |
|  1st  | n.s. | 25 | 2012f | cat. Methanation | Germany |  |  | (Krautkremer, 2017) |
|  2nd  | PEM | 50 | 2018f | cat. Methanation | Germany |  |  | (Schröer and Krautkremer, 2016; Maaz, 2017) |
| Power to Gas at Eucolino | n.s. | 108 | 2012f | cat. Methanation | Germany | n.s. | Biogas | (dena, 2012b) |
| Hybrid power plant Falkenhagen - STORE&GO Germany | Alkaline | 2000 | 2013 | cat. Methanation | Germany | Wind | Bio-ethanol plant | (DVGW, 2016) |
| Audi e-gas | Alkaline | 6000 | 2013 | cat. Methanation | Germany | Wind | n.s. | (Köbler, 2013) |
| Foulum | n.s.  | 250 | 2013f | bio. Methanation | Denmark | Surplus | Biogas | (Byman et al., 2013) |
| Viessmann microbial methanation | PEM | 275 | 2013f | bio. Methanation | Germany | Surplus | Biogas | (Viessmann, 2015) |
| Emden | n.s. | n.s. | 2013f | bio. Methanation | Germany | Wind | WWT plant | (Steinigeweg, 2012) |
| Rozenburg | Alkaline | 8.3 | 2014 | cat. Methanation | The Netherlands | PV + Renewables (certificate) | n.s. | (Vlap et al., 2015) |
| Thüga demonstration plant | PEM | 300 | 2014f | - | Germany | Renewables (certificate) | - | (Thüga, 2014) |
| RWE demonstration plant | PEM | 150 | 2015 | - | Germany | n.s. | - | (RWE, 2015) |
| WindGas Hamburg | PEM | 1000 | 2015f | - | Germany | Wind | - | (uniper, 2016) |
| Energiepark Mainzc | PEM | 6000 | 2015 | - | Germany | Wind | - | (Energiepark Mainz, 2016) |
| Energy Storage – Hydrogen Injected into the Gas Grid via Electrolysis Field Test | PEM | 5.5 | 2015 | - | Denmark | Grid | - | (Bruun et al., 2014) |
| DemoSNG | PEM | ~60 | 2015 | cat. Methanation | Sweden | Renewables (certificate) | Biomass | (Graf, 2014) |
| BioPower2Gas | PEM | 300 | 2015 | bio. Methanation | Germany | Grid | Biogas | (IdE, 2015; Sveinbjörnsson and Münster, 2017) |
| Hybrid power plant Aarmatt - STORE&GO Switzerland | PEM | 700 | 2015 | bio. Methanation (2019) | Switzerland | PV | WWT plant | (DVGW, 2016) |
| MeGa-stoRE |  |  |  |  |  | Renewables (certificate) | Biogas | (Aarhus University, 2015; Tornberg, 2015) |
|  1 | Alkaline | 6 | 2014f | bio. Methanation | Denmark |  |  |
|  2 | Alkaline | 250 | 2016f | bio. Methanation | Denmark |  |  |
| El upgraded biogas | SOEC | 50 | 2016 | cat. Methanation | Denmark | Grid | Biogas | (Hansen, 2017; Sveinbjörnsson and Münster, 2017) |
| BioCat Project/POWERSTEP | Alkaline | 1200 | 2016 | bio. Methanation | Denmark | Grid | WWT plant | (Forstmeier, 2016; Sveinbjörnsson and Münster, 2017) |
| Energy park Pirmasens-Winzeln | Alkaline | 2500 | 2016 | bio. Methanation | Germany | Surplus | Biogas | (pfi Germany, 2017) |
| bioCONNECT | PEM | n.s.  | 2016f | bio. Methanation | Germany | Renewables (certificate) | Bio-ethanol plant | (HS-OWL, 2015) |
| Ingrid – STORE&GO Italy | PEM | 1000 | 2016 | cat. Methanation | Italy | Wind, PV | DAC | (DVGW, 2016) |
| Renovagas | Alkaline SPE | 15 | 2016 | bio. Methanation | Spain | Renewables (certificate) | Biogas | (Rubio et al., 2016) |
| HELMETH | SOEC | 15 | 2017 | cat. Methanation | Germany | Wind, PV | Biogas | (Founti, 2016) |
| Minerve | SOEC | n.s. | 2017 | n.s. Methanation | France | Grid | n.s. | (AFUL, 2017) |
| Kommunaler Energieverbund Freiburg | PEM | 120 | 2017 | - | Germany | n.s. | - | (Voglstätter et al., 2018) |
| COSYMA | n.s. | n.s. | 2017 | cat. Methanation | Switzerland | n.s. | Biogas | (Biollaz et al., 2017) |
| GRYHDb | PEM  | 44 | 2018 | - | France | Wind | - | (Trondl and Gellbert, 2018) |
| CO2-SNG | PEM | 122  | 2018 | cat. Methanation | Poland | n.s | Coal power plant | (Chwoła et al., 2020) |
| Jupiter 1000 | Alkaline/ PEM | 500+ 500 | 2018 | cat. Methanation | France | Renewables (certificate) | Industry | (GRTgas, 2016) |
| Symbio | n.s.  | n.s. | 2018 | bio. Methanation | Denmark | Wind | Biogas | (DTU, 2013) |
| CoSin | Alkaline | n.s. | 2018 | cat. Methanation | Spain | Wind | WWT plant | (Guilera et al., 2020) |
| HyDeploy | PEM | 500 | 2019 | - | United Kingdom | n.s. | - | (Markillie, 2016) |
| Wind to Gas | PEM | 2400 | 2019 | - | Germany | Wind | - | (Wind to Gas energy, 2017) |
| HyStock | PEM | 1000 | 2019 | - | The Netherlands | Wind, PV | - | (Ekinetix, 2018; energystock, 2019) |
| SYNFUEL | SOEC | n.s.  | 2019 | cat. Methanation | Denmark | Renewables (certificate) | Biomass gasification | (Hendriksen, 2015) |
| Energie des Nordens | PEM | 1000 | 2020 | - | Germany | Wind | - | (Power to X Allianz, 2019) |
| Swisspower Hybridkraftwerk | PEM | 2000 | 2021 | bio. Methanation | Switzerland | MWT plant | WWT plant | (Viessmann, 2019; Solarserver, 2020) |
| MethyCentre | PEM |  125  | 2021 | Methanation | France | Renewables (certificate) | Biogas | (Storengy, 2020) |
| Element Eins | n.s. |  100,000  | 2022 | - | Germany | Wind | - | (E1, 2019) |
| H2V Product |  |  |  |  |  | Renewables (certificate) | - | (HydrogenPro, 2019) |
|  H2V59 | Alkaline | 100,000 | 2022 | - | France |  |  | (H2V, 2020) |
|  H2V Normandy | Alkaline | 400,000 | 2023 | - | France |  |  | (Meillaud, 2019) |
| hybridge | n.s. |  100,000  | 2023 | cat. Methanation  | Germany | Renewables (certificate) | n.s. | (hybridge, 2019) |
| PEGASUS Project | n.s. | n.s. | projected | Methanation | Italy | Renewables (certificate) | Biogas | (SGI, 2019) |
| Power-to-Gas Hungary | n.s. | 10,000 | projected | bio. Methanation | Hungary | Renewables (certificate) | n.s. | (PowertoGas Hungary, 2019) |
| **Heat and power generation** |  |  |  |  |  |  |  |  |
| HARI | Alkaline | 36 | 2004f | - | United Kingdom | Hydropower | - | (Gammon et al., 2006) |
| Utsira | Alkaline | 50 | 2004f | - | Norway | Wind | - | (Statoil, 2004) |
| Vestenskov | n.s.  | n.s.  | 2006f | - | Denmark | Wind | - | (DAC&CITIES, 2009) |
| RES2H2 Pozo Izquierdo | Alkaline | 100 | 2007f | - | Spain | Wind | - | (Argumosa and Cambreleng, 2009) |
| Hídrolica | PEM | 30 | 2007f | - | Spain | Wind | - | (Andalusian Energy Agency, 2011) |
| H2 from the Sun | Alkaline | 6.7 | 2007f | - | Italy | PV | - | (Argumosa et al., 2010) |
| HYRES | PEM | 4.5 | 2008f | - | Greece | Wind, PV | - | (Voutetakis, 2015) |
| Samsø | n.s. | 20 | 2008 | - | Denmark | Wind, PV | - | (Korsbæk and Pedersen, 2007) |
| Abalone Energie | Alkaline | n.s. | 2009f | - | France | Wind, PV | - | (Hydrogenics, 2010) |
| H2KT | Alkaline | 100 | 2010 | - | Denmark | Hydropower | - | (Nielsen, 2010) |
| Greenhouse Apulia | PEM | 2.5 | ~2012 | - | Italy | PV | - | (Pascuzzi et al., 2016) |
| Hydrogen Office | n.s. | 30.0 | 2012 | - | United Kingdom | Wind | - | (BGH, 2010) |
| Myrte | PEM | 210 | 2013 | - | France | Grid | - | (FCB, 2014) |
| RH2-WKA Grapzow | Alkaline | 1000 | 2013 | - | Germany | Wind | - | (WIND-WASSERSTOFF-projekt 2016) |
| La Croix Valmer | PEM | n.s. | 2014 | - | France | PV | - | (Curtin and Gangi, 2015) |
| Spring Bank Farmb | Alkaline SPE | 4.8 | 2014 | - | United Kingdom | Wind, PV | - | (Acta, 2016) |
| El Tubo | Alkaline SPE | 2.4 | 2015 | - | Spain | PV | - | (Bert, 2015) |
| Exytron demonstration project | Alkaline | 21 | 2015 | cat. Methanation | Germany | PV | Natural gas | (Schirmer, 2020) |
| Stromlückenfüller |  |  |  |  |  | Wind | - | (Rentzing, 2016) |
| Test | PEM | 20 | 2015f | - | Germany |  |  |  |
| Pilot phase | PEM | 200 | ~2018f | - | Germany |  |  | (H-TEC SYSTEMS, 2020) |
| Power-to-Gas Haßfurt/ E2Fuel | PEM | 1250 | 2016 | Methanol (starting 2020) | Germany | Wind | n.s. | (Pyc and Zimmermann, 2018) |
| Smart Grid Solar | PEM | 75 | 2016 | - | Germany | PV | - | (Gossens, 2016) |
| Power-to-Flex | Alkaline  | n.s. | 2018 | bio. Methanation, Methanol | Germany/ The Netherlands | Renewables (certificate) | Biogas | (Power to Flex, 2016) |
| HYPOS LocalHy | Alkaline | 250 | 2019 | - | Germany | Renewables (certificate) | - | (localhy, 2019) |
| Klimafreundliches Wohnen | Alkaline | 52 | 2019 | cat. Methanation | Germany | PV | Natural gas | (Wohnbaugruppe, 2019) |
| Haeolusb | PEM | 2000 | 2020 | - | Norway | Wind | - | (Haeolus, 2018) |
| REFLEX | SOEC | n.s. | 2020 | - | Italy | Renewables (certificate) | - | (Mougin, 2018) |
| Exytron Bernsteinsee | Alkaline | 52 | 2020 | cat. Methanation | Germany | PV+grid | Natural gas | (Exytron, 2019) |
| Rostock hydrogen | Alkaline | 2000 | 2020 | - | Germany | Renewables (certificate) | - | (Jendrischik, 2020; Reuters, 2020) |
| Hotflex | SOEC | 150 | ~2020 | - | Austria | Renewables (certificate) | - | (sunfire, 2019) |
| Exytron Zurich | Alkaline | 52 | 2021 | cat. Methanation | Switzerland | PV | Natural gas | (Schirmer, 2020) |
| Energieversorgung Lübesse | Alkaline | 10,000 | ~2021 | cat. Methanation | Germany | Wind, PV | Biogas | (Kaulmann, 2020; Schirmer, 2020) |
| Exytron Hesse | Alkaline |  52  | ~2022 | cat. Methanation | Germany | PV | Natural gas | (Schirmer, 2020) |
| Exytron North Rhine-Westphalia | Alkaline |  100  | ~2022 | cat. Methanation | Germany | PV | Natural gas | (Schirmer, 2020) |
| Exytron East Bavaria | Alkaline |  100  | ~2022 | cat. Methanation | Germany | PV | Natural gas | (Schirmer, 2020) |
| Vårgårda housing | Alkaline | ~ 300  | 2022 | - | Sweden | PV | - | (Jensen, 2020) |
| HYFLEXPOWER | PEM |  n.s.  | ~2023 | - | France | Renewables (certificate) | - | (Siemens Gas and Power et al., 2020) |
| Referenzkarftwerk Lausitz | PEM |  10,000  | 2023 | - | Germany | Surplus | - | (BMWi, 2019; Hänel et al., 2019) |
| **Fuels** |  |  |  |  |  |  |  |  |
| HyFLEET:CUTE Hamburg | Alkaline | 400 | 2003f | - | Germany | n.s. | - | (HyFLEET:CUTE, 2009) |
| HyFLEET:CUTE Amsterdam | Alkaline | 400 | 2003f | - | The Netherlands | n.s. | - | (Haraldsson et al., 2005; HyFLEET:CUTE, 2009) |
| HyFLEET:CUTE Barcelona | Alkaline | 400 | 2003f | - | Spain | PV + grid | - | (Busby, 2005; HyFLEET:CUTE, 2009) |
| HyFLEET:CUTE Stockholm | Alkaline | 400 | 2003f | - | Sweden | Renewables (certificate) | - | (HyFLEET:CUTE, 2009) |
| ECTOS | Alkaline | 300 | 2003f | - | Iceland | Grid | - | (Icelandic New Energy, 2013) |
| PURE | Alkaline | 18 | 2005f | - | United Kingdom | Wind | - | (Lumsden, 2011) |
| RES2H2 Keratea | Alkaline | 25 | 2005f | - | Greece | Wind | - | (Varkaraki, 2009) |
| Chic Aargau | Alkaline | 300 | 2011f | - | Switzerland | PV | - | (PostAuto, 2012) |
| George Olah Plant |  |  |  |  |  | Geothermal | Geothermal | (Steffansson, 2015) |
|  1. | Alkaline | ~1700 | 2011 | Methanol | Iceland |  |  |
|  2. | Alkaline | ~5200 | 2014 | Methanol | Iceland |  |  |
| Hydrogen refuelling station HafenCity | Alkaline | 600 | 2012 | - | Germany | Renewables (certificate) | - | (Wulf et al., 2011) |
| Solar hydrogen filling station Freiburg | PEM | 30 | 2012 | - | Germany | PV | - | (Fraunhofer ISE, 2012) |
| Herten hydrogen centre of excellence | Alkaline | 280 | 2013 | - | Germany | Wind | - | (Armata, 2013; Brautmeier, 2015) |
| Hydrogen filling station Stuttgart | Alkaline | 400 | 2013f | - | Germany | Renewables (certificate) | - | (EnBW, 2017) |
| Sunfire Research project | SOEC | 10 | 2014f | Fischer-Tropsch | Germany | Renewables (certificate) | DAC | (BMBF, 2015) |
| Sunfire Power-to-Liquids | SOEC | 150 | 2014 | Fischer-Tropsch | Germany | Renewables (certificate) | DAC | (Jendrischik and Aldag, 2014) |
| Multi-energy fueling station H2BERd  | Alkaline | 500 | 2014 | - | Germany | Renewables (certificate) | - | (Total, 2014) |
| Power to Gas Biogasboostere | n.s. | 10 | 2014 | bio. Methanation | Germany | Surplus | WWT plant | (dena, 2015) |
| M1 Wind Hydrogen Refuelling station | PEM | 100 | 2015 | - | United Kingdom | Wind | - | (Pearce, 2015) |
| Wind2Hydrogen | PEM | 100 | 2015 | - | Austria | Wind | - | (OMV, 2015) |
| Power-2-Hydrogen-Tankstelle | PEM | 185 | 2015 | - | Germany | Renewables (certificate) | - | (Falk, 2016) |
| H2 Aberdeen: Hydrogen Bus Project | Alkaline | 1000 | 2015 | - | United Kingdom | n.s. | - | (Aberdeen City Promotions, 2016) |
| Rapperswil | Alkaline | 25 | 2015 | cat. Methanation | Switzerland | PV | DAC | (IET, 2017) |
| Levenmouth Community Energy Projectg | Alkaline/ PEM | 2x60 + 250 | 2016 | - | United Kingdom | Wind, PV | - | (Todd, 2016) |
| Don Quichote | PEM | ~130 | 2016 | - | Belgium | Wind, PV | - | (Seykens, 2017) |
| HyFive London 1 | PEM | 100 | 2016 | - | United Kingdom | Renewables (certificate) | - | (Pearce, 2015; HyFIVE, 2016) |
| HyFive London 2 | PEM | 100 | 2016 | - | United Kingdom | Renewables (certificate) | - |
| HyFive London 3 | PEM | 100 | 2017 | - | United Kingdom | Renewables (certificate) | - |
| H2 Mobility - Karlsruhe | SOEC | 9.4 | 2017 | - | Germany | PV | - | (DWV, 2017) |
| FaHyance | Alkaline | 57 | 2017 | - | France | Renewables (certificate) | - | (Colomar, 2017) |
| BIGH2IT | PEM | 1500 | 2018 | - | United Kingdom | Wind, Tide | - | (BIGH2IT, 2017) |
| Herten hydrogen centre of excellence | Alkaline | n.s. | 2018 | - | Germany | Renewables (certificate) | - | (Geitman, 2018) |
| Hydrogen Mobility Europe | n.s. | n.s. | 2018 | - | Iceland | n.s. | - | (Gudmundsdottir, 2018) |
| HyBalance | PEM | 1200 | 2018 | - | Denmark | Wind | - | (Hydrogen Valley, 2017) |
| H2energy | PEM | 200 | 2018 | - | Switzerland | Hydropower | - | (H2energy, 2017) |
| Swinden | PEM | 100 | 2018 | - | United Kingdom | Renewables (certificate) | - | (ITM, 2020e) |
| Beaconsfield | PEM | 100 | 2018 | - | United Kingdom | n.s. | - | (ITM, 2020a) |
| HyWay | Alkaline | 156 | 2018 | - | France | Renewables (certificate) | - | (McPhy, 2018) |
| Kopernikus Power-to-X I | SOEC | 10 | 2018 | Fischer-Tropsch | Germany | Grid | DAC | (BMBF, 2018; Jendrischik, 2019) |
| Gatwick | PEM | 100 | 2019 | - | United Kingdom | Renewables (certificate) | - | (ITM, 2020c) |
| Bus Artois-Gohelle | Alkaline |  500  | 2019 | - | France | Renewables (certificate) | - | (McPhy, 2019) |
| MefCO2 | PEM | 1000 | 2019f | Methanol | Germany | Renewables (certificate) | Coal power plant | (MefCO2, 2019) |
| FReSMe | n.s. |  n.s.  | 2019 | Methanol | Sweden | Surplus, renewable | Steel industry | (FReSMe, 2017; Swedish Hydrogen Development Center, 2019) |
| Flagship project: Power-to-Gas Baden-Württemberg | Alkaline | 1000 + 300 | 2019 | - | Germany | Hydropower | - | (Del Regno and Vartmann, 2016; Büssers, 2019) |
| H2 Nodes Pärnu | PEM |  1000  | 2019 | - | Estonia | Renewables (certificate) |  | (Løkke and Simonsen, 2017) |
| H2 Nodes Riga | PEM |  1000  | 2020 | - | Latvia | Renewables (certificate) | - | (FuelCellsWorks, 2020b) |
| Wasserkraft Gösgen | n.s. | 2000 | 2020 | - | Switzerland | Hydropower | - | (Alpiq, 2019) |
| Birmingham | PEM | 100 | 2020 | - | United Kingdom | n.s. | - | (ITM, 2020b) |
| Kläranlage Sonneberg-Heubisch | Alkaline | 5630 | 2020 | - | Germany | Renewables (certificate) | - | (Jentsch and Büttner, 2019) |
| Refuelling station Ellhöft | PEM | 250 | 2019 | - | Germany | Wind | - | (Friedrich, 2018) |
| Infinity 1 | PEM | 1000 | 2020 | bio. Methanation | Germany | Surplus, renewable | WWT plant | (Hausemer and Pentz, 2017; Schattenhofer, 2017) |
| Nachbarschaftsqurtier Fliegerhorst Oldenburg | n.s. | n.s. | 2020 | - | Germany | Wind, PV | n.s. | (Meister, 2019) |
| eFarm | PEM | 1125 | 2020 | - | Germany | Wind | - | (Joule, 2019) |
| WUNsiedler Weg | PEM | 10,000 | 2021 | (Methanol) | Germany | Surplus, renewable | n.s. | (Schmuderer, 2019; SWW, 2019) |
| Wasserstoff – grünes Gas für Bremerhaven | PEM | n.s. | 2021 | - | Germany | Wind | - | (Rösener and Stührenberg, 2019; Steinau and Wellbrock, 2019) |
| Power to Green Hydrogen (Green Spider) | PEM |  10,000  | 2021 | - | Spain | PV | - | (Doyle, 2019; Sureda Bonnin, 2019) |
| Kopernikus Power-to-X II | SOEC | 150 | 2021 | Fischer-Tropsch | Germany | Grid | DAC | (KIT Webcast, 2020)g |
| H2OUEST | n.s. |  n.s.  | 2021 | - | France | Wind | - | (FuelCellsWorks, 2020c) |
| 2020 HYPE 600 | n.s. |  n.s.  | ~2021 | - | France | Renewables (certificate) | - | (Air Liquide, 2020) |
| PERLE | n.s. |  n.s.  | 2021 | - | France | PV | - | (FuelCellsWorks, 2020a) |
| Dijon Métropole Smart Energhy 2 | n.s. | ~1.000  | 2022 | - | France | PV | - | (Choplain, 2020) |
| HYBER | n.s. | ~850 | ~2022 | - | France | PV | - | (Pousset, 2020) |
| H2V CORSTYRENE | n.s. | n.s. | ~2022 | - | France | PV | - | (FuelCellsWorks, 2020a) |
| Montpellier Horizon Hydrogène | n.s. |  n.s.  | 2022 | - | France | PV | - | (Chaigneau, 2020) |
| Hellesylt Hydrogen Hub | n.s. | 5000 | 2023 | - | Norway | Hydropower | - | (Vislie, 2019) |
| Liquid Wind | n.s. | ~1100 | 2023 | Methanol | Sweden | Renewables (certificate) | Industry | (Liquid Wind, 2020) |
| Glomfjord Hydrogen | Alkaline | 2000 | 2023 | - | Norway | Hydropower | - | (Damman et al., 2020; Ulsnæs, 2020) |
| H2RES | n.s. | 2000 | ~2023 | - | Denmark |  |  | (Korsgaard, 2019) |
| Herøya jet fuel | SOEC | 20,000 | 2023 | Fischer-Trospsch | Norway | Renewables (certificate) | DAC | (Nordic Blue Crude, 2020; Norsk e-fuel, 2020) |
| HyGreen Provenced |  |  |  |  |  | PV | - | (Le Hen, 2019; Saveuse, 2020) |
| 1 | n.s. |  17,000  | 2023 | - | France |  |  |
| 2 | n.s. |  130,000  | 2026 | - | France |  |  |
| 3 | n.s. |  435,000  | 2030 | - | France |  |  |
| AQUAPrimus | n.s. | 20,000 | 2024 | - | Germany | Wind | - | (N.N., 2020; Singer, 2020) |
| H2 Wyhlenc | Alkaline | 10,000 | ~2024 | - | Germany | Hydropower | - | (BMWi, 2019) |
| SmartQart | n.s. | n.s. | ~2024 | - | Germany | Renewables (certificate) | - | (Enrgiewende Bauen, 2019) |
| Greenlab P2X | n.s. | 12,000 | ~2024 | Methanol | Denmark | Renewables (certificate) | n.s. | (Thomsen, 2019) |
| Reallabor Lausitz | n.s. | n.s. | ~2024 | - | Germany | Wind | - | (Kunipatz, 2019) |
| HyPort | n.s.  |  50.000  | 2025 | - | Belgium | Renewables (certificate) | - | (Port Oostende, 2020) |
| Wasserstofftankstelle Kirchheim | n.s. | ~30 | projected | - | Germany | Wind | - | (Brill, 2019) |
| HyPerformer |  |  |  |  |  |  |  | (NOW, 2019) |
| HyBayern | n.s. | n.s. | projected | - | Germany | Hydropower | - | (Tix, 2020) |
| Hyways for Future | n.s. | n.s. | projected | - | Germany | Renewables (certificate) | - |  |
| H2Rivers | n.s. | n.s. | projected | - | Germany | Renewables (certificate) | - |  |
| **Hydrogen for industry** |  |  |  |  |  |  |  |  |
| Sotavento | Alkaline | 300 | 2007f | - | Spain | Wind | - | (Correas and Aso, 2010; Sotavento Galicia, 2017) |
| CO2RRECT | PEM | 300 | 2013f | Synthesis gas, Formic acid | Germany | Renewables (certificate) | Coal power plant | (Rieks, 2011; Bär, 2014) |
| Osshy Pushy | Alkaline | 60 | 2013 | - | France | Grid | - | (Afhypac, 2014) |
| Lashy Pushy | Alkaline  | 65 | n.s. | - | France | Renewables (certificate) | - | (Afhypac, 2014) |
| Hanau | PEM | 35 | 2015 | - | Germany | Renewables (certificate) | - | (Focht, 2015) |
| H&R Ölwerke Schindler | PEM | 5000 | 2017 | - | Germany | Renewables (certificate) | - | (BUE, 2016; H&R, 2017) |
| H2Orizona | PEM | 350 | 2018 | - | Germany | Wind | - | (H2 Orizon, 2019) |
| bioeconomy+d | PEM | 25 | 2018 | SNG, Methanol, Waxes | Finnland | Renewables (certificate) | Biomass | (Karki, 2018) |
| GrInHy |  |  |  |  |  | Renewables (certificate) | - |  |
| GrInHy | SOEC | 143 | 2018 | - | Germany |  |  | (GrinHy, 2020) |
| GrInHy 2.0 | SOEC | 720 | 2021 | - | Germany |  |  | (dena, 2019) |
| H2Future | PEM | 6000 | 2019 | - | Austria | Renewables (certificate) | - | (voestalpine, 2019) |
| ALIGN-CCUS | Alkaline | ~65 | 2020 | DME | Germany | Grid | Coal power plant | (Moser et al., 2018) |
| REFHYNE | PEM | 10,000 | 2020 | - | Germany | Renewables (certificate) | - | (REFHYNE, 2019) |
| Wind Hydrogen energy project | PEM | 2200 | 2020 | - | Germany | Wind | - | (Salzgitter AG, 2019) |
| MethFuel | PEM | 1000 | 2020 | catalytic | Germany | Renewables (certificate) | CHP, DAC | (MethQuest, 2020) |
| HYPOS MegaLyseurPlus | PEM | 1250 | 2021 | - | Germany | n.s. | - | (HYPOS, 2019) |
| HYBRIT | Alkaline | 4.500 | 2021 | - | Sweden | Renewables (certificate) | - | (HYBRIT, 2018; Løkke and Simonsen, 2019) |
| Delfzijl refinery | n.s. | n.s. | 2022 | - | The Netherlands | Renewables (certificate) | - | (SkyNRG, 2019) |
| Energiepark Bad Lauchstädtb | n.s. | 35,000 | 2023 | - | Germany | Wind | - | (Ackermann, 2019) |
| HYOFFWIND | n.s.  |  25.000  | 2023 | - | Belgium | Renewables (certificate) | - |  (fluxys, 2020) |
| PtG for the refining process Lingen | n.s. | 15,000 | 2024 | - | Germany | Renewables (certificate) | Biomass | (Uniper and BP, 2017; Schulte and Karczmarzyk, 2019) |
| GreenHydroChem | PEM  |  50,000  | 2024 | Fuels | Germany | Renewables (certificate) | n.s. | (BMWi, 2019) |
| MultiPLHY | SOEC | 2600 | 2023 | - | The Netherlands | Renewables (certificate) | - | (European Commission, 2020; Ulbricht, 2020) |
| HEAVENNb | Alkaline | 20,000 | ~2024 | Methanol | The Netherlands | Renewables (certificate) | biomass | (Groningen Seaports, 2020) |
| HySynergy | n.s. | 20,000 | ~2024 | - | Denmark | Renewables (certificate) | - | (Krogsgaard and Sørensen, 2019) |
| HydroHub Fenne | PEM  |  17,500  | ~2024 | - | Germany | Renewables (certificate) | - | (BMWi, 2019) |
| H2Stahl | Alkaline |  n.s.  | ~2024 | - | Germany | Renewables (certificate) | - | (BMWi, 2019) |
| Westküste 100 | Alkaline | 30,000  | ~2024 | - | Germany | Wind | - | (Westküste 100, 2019) |
| Norddeutsche Reallabore | n.s.  |  77,000  | ~2024 | - | Germany | Renewables (certificate) | - | (BMWi, 2019) |
| CCU P2C Salzbergen | n.s. |  n.s.  | ~2024 | Cat. Methanation | Germany | Renewables (certificate) | MWT plant | (BMWi, 2019) |
| NorthH2 | n.s. |  n.s.  | 2027 | - | The Netherlands | Wind | - | (Gasunie, 2020) |
| Gigastack | PEM | 20,000  | projected | - | United Kingdom | Wind | - | (ITM, 2020d) |
| Preem Gothenborg | n.s. |  20.000  | projected | - | Sweden | Renewables (certificate) | - | (Kollberg and Kryssare, 2019) |
| GET H2b | PEM | n.s. | projected | - | Germany | Renewables (certificate) | - | (Steffen et al., 2019) |
| Austrian hydrogen industry | n.s. | n.s. | projected | - | Austria | Renewables (certificate) | - | (Metelko, 2019) |
| Leuchtturm Hamburg | PEM | 100,000  | projected | - | Germany | Renewables (certificate) | - | (koe, 2019) |
| **Usage of gas not specified** |  |  |  |  |  |  |  |  |
| ITHER | Alkaline/ PEM | 63+7 | 2010f | - | Spain | Wind, PV | - | (Correas and Aso, 2010) |
| SEE | PEM | 6 | 2011f | - | Germany | PV | - | (Fraunhofer ISE, 2014) |
| PtG 250 | Alkaline | 250 | 2012 | cat. Methanation | Germany | n.s. | n.s. | (Zuberbühler, 2011) |
| Hydrogen Centre | Alkaline/ PEM | 55 + 12+~1 | 2012 | - | United Kingdom | Wind, PV | - | (Armata, 2013; University of South Wales, 2017) |
| ESI Platform | PEM | 100 | 2016 | cat. Methanation | Switzerland | PV | Wood gasification | (Büchi and Schmidt, 2015) |
| Underground Sun Storageh | Alkaline | 600 | 2016 | - | Austria | PV | - | (Bauer, 2016) |
| HPEM2Gas | PEM | 180 | 2019 | - | Germany | Surplus | - | (Grahl-Madsen, 2017) |
| HYPOS rSOC | SOEC | n.s. | 2020 | - | Germany | Surplus, renewable | - | (Posdziech, 2018) |
| cec clean energy conversion | PEM |  4000  | 2021 | - | Germany | Wind | - | (cec, 2019) |
| Demo4Grid | Alkaline | 4000 | 2021 | - | Austria | Renewables (certificate) | - | (FEN Sustain System, 2017; Perwög, 2019) |
| Energiewendelabor Ketzin | n.s. | n.s. | projected | - | Germany | Wind, PV | - | (Krautz, 2019) |
| Sava Power-to-Gas | n.s. |  n.s.  | projected | - | Slovenia | Hydropower | - | (HESS, 2019) |
| North sea wind power hub | n.s. | n.s. | projected | - | Europe | Wind | - | (NSWPH, 2019) |
| DAC – direct air capture; MWT – municipal waste treatment; n.s. - not specified; PEM - polymer electrolyte membrane; PV – photovoltaics; SOEC - solid oxide electrolysis cell; SPE - solid polymeric electrolyte; WWT – waste water treatment |
| a: H2 also for mobility and CHP; b: H2 also for mobility; c: H2 also for mobility and industry; d: H2 also for CHP, industry and natural gas grid; e: CH4 also for natural gas grid; f: plant decommissioned; g: H2 also for natural gas grid and re-electrification; h: Main objective: underground storage of H2 |

Table 2 Envisaged European IPCEI (Important Project of Common European Interest) projects

| **Name of the project** | **Type of Electrolyzer** | **Capacity kW** | **Application** | **Countries** | **Source**  |
| --- | --- | --- | --- | --- | --- |
| Green Spider |  |  |  | Spain, The Netherlands, Germany |  (Martínez Rodríguez and Teichmann, 2019) |
| Aragón Hub  | n.s. |  50,000  | Blending | Spain |
| Castilla y León Hub  | n.s. |  100,000  | Blending, Fuels | Spain |  |
| País Vasco Hub | n.s. |  150,000  | Industry | Spain |  |
| Asturias Hub  | n.s. |  100,000  | Industry | Spain |  |
| White Dragon | SOEC | 670,000 | CHP | Greece, Italy, Germany, Belgium | (Stubos and Bucheli, 2019) |
| H2 Go | n.s. | 500,000 | Fuels | Romania, Bulgaria, Hungary, Slovenia, Austria, Germany | (OMV, 2019) |
| Blue Dolphin | n.s. | 600,000 | Fuels | Italy, France, Germany, Belgium, The Netherlands | (Guglia, 2019) |
| Silver Frog | PEM | 10,000,000 | Industry | Italy, Germany, Belgium, Slovakia, Denmark | (Hengst et al., 2019) |
| Green Hydrogen @ Blue Danube | PEM | 1,800,000 | Industry, Fuels | Croatia, Hungary, Germany, Austria, Bulgaria, Romania, Serbia, The Czech Republic, Italy | (Zauner and Seitz, 2019) |
| Black Horse | n.s. | 16,500,000 | Fuel | Poland, The Czech Republic, Slovakia, Hungary | (Halasz, 2019) |
| Green Flamingo | n.s. | 5,000,000 | Industry, Fuels | Portugal, The Netherlands, Denmark, Germany | (Rechter, 2020) |
| Rainbow Unhycorn | n.s. | 400,000 | Fuels | France, The Netherlands, Germany, Spain, Norway, Romania, Belgium, Serbia | (Bouillon Delporte and Brossard, 2019) |
| Green Octopus | n.s. | 6,000,000 | Industry, Fuels | Belgium, The Netherlands, Germany, France, Denmark | (Hillegeer et al., 2019) |

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