SMARTENERGY

2,5 GW H_2 Electrolyser capacity by 2030 – opportunity and challenge for developers

The path to 2.5 GW of Green Hydrogen, Portugal Renewable Energy Summit
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Christian Pho Duc, CTO & Managing Director H_2 Projects SMARTENERGY Group AG

Smartenergy, 10 years of commitment to PV, Wind and Green Hydrogen in Europe

Core competences

- Electricity supply from Renewables for on-grid and off-grid projects
- Developing project finance projects and availability of funding mechanism to overcome initial market failures
- Setting up solutions along the value chain including Permitting
- Large scale, reliable and cost competitive Green Hydrogen production

Our offices in Europe

+3 GW
PV Portfolio

+750 MW
H_2 projects pipeline, including IPCEI and Green Deal applications

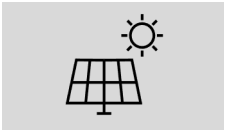
+ 70
employees

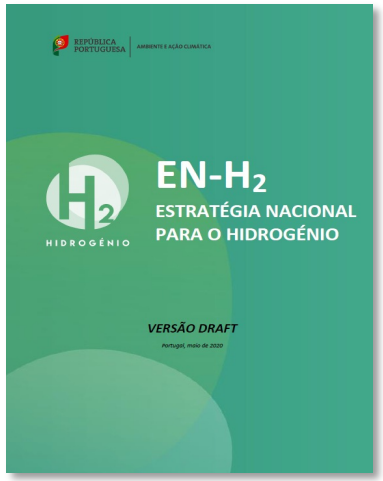
+10 dedicated H_2 team technical and regulatory and public affairs

2018-2021

Huge renewables deployment and overcoming H2 project barriers is needed in Portugal for the achievement of the 2.5GW EL H2

Prospects for the evolution of the installed capacity for electricity production in Portugal (PNEC 2020 & H2 Strategy)

	2025	2030
	6.8 GW	9.3 GW
	6.6 GW	9,0 GW
H2 production capacity (Sines)	250-300 MW	1 - 1.5 GW
H2 production capacity decentral	150-200 MW	0.5 - 1 GW
H2 production small units <5 MW	50 MW	100 MW



- Land availability / public acceptance
- Grid connection / fees
- Intensive energy users legislation and support
- Funding scheme
- Integration into EU “waves”

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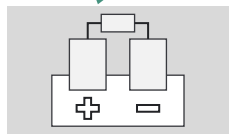


2,5GW

2030

Calibrating projects to optimize LCOE becomes the critical factor for commercial viability

Green H_2-production parameters in Portugal (indicative numbers)

Technical characteristics	PV only	+ grid electricity at selected tariff windows[1)]	+ grid electricity at any time [2)]
Achievable Load factor Electrolyzer	c. 35%	c. 53%-69%	c. 100%
Required Electrolyzer size (MW)	c. 120	c. 60-80	c. 43
Required PV capacity, with tracker (MW)	c. 230	c. 165	c. 130
Estimated LCOH (EUR/kg H_2)	c. 3.9-4.2 EUR	c. 3.5-4.2 EUR	c. 3.4–4.2 EUR

- Assumption based on 50MW EL.
- Adding grid electricity, increases the Load Factor and enables a more continuous production.
- LCOH become less dependent on Electrolyzer CAPEX, but are strongly influenced by OPEX (electricity costs from the grid, including fees)
- Each setup has its benefits, depending on specific project characteristics

1) For example at night or during weekends, when there are lower grid fees. This depends on country-specific grid regulation.
2) Operating the Electrolyzer at full capacity and import electricity at "any cost". In this case, we would also

Source: SMARTENERGY Group AG

Development of a 20+20 MW electrolyser to supply green H_2 to mobility offtakers

Our key focus areas for matchmaking[1]:

- **Mobility offtakers in the region**, e.g., fleet operators
- **HRS operators in the region,** e.g., for private or public refilling

Source: SMARTENERGY Group AG

Photovoltaics	**35+95[2] MWp**
Power grid connection	**Yes (grid tbc.)**
Electrolyser	**20-40[3] MW**
Annual H_2 output	**up to c. 4,800[4] tons**

Offtake model[1]: Mobility offtakers

Value chain components covered:

- Electricity generation from PV and import from grid
- Green H2 production via electrolysis
- Road transport via trucks + HRS at offtakers' site (via partners)

Additional information:

- Preliminary technical design study (with ThyssenKrupp) concluded
- Prior registration as gas producer at DGEG (licensing authority) has been obtained; permits and authorizations for new PV site are being secured

1) Project initially designed for offtake by mobility firms; other offtake models (e.g., industry, int'l offtakers) conceivable if specific opportunities arise; 2) New off-grid PV Plant (35 MWp) under dev. + grid-connected PV plants Mogadouro & Betty (95 MWp); 3) 20 MW built in 1st phase, 20 MW to be pot. added; 4) 40 MW electr.

Development of a 100 MW EL project for for gas grid injection and support growing demand in transport and mobility in the region

Our key focus areas for matchmaking[1]:

- Industry offtakers of green H_2 connected to Iberian natural gas grid
- Industry offtakers of green H_2 (as feedstock) in Iberia (e.g. ammonia, methanol)
- International industry offtakers of green H_2 to be served via other means of transport

Photovoltaics	150 MWp
Power grid connection	Off-grid (grid tbd.)
Electrolyser	100 MW
Annual H_2 output	up to c. 4,450 tons

Value chain components covered:

- Electricity generation from PV
- Battery storage for load stabilization
- Green H_2 production via electrolysis

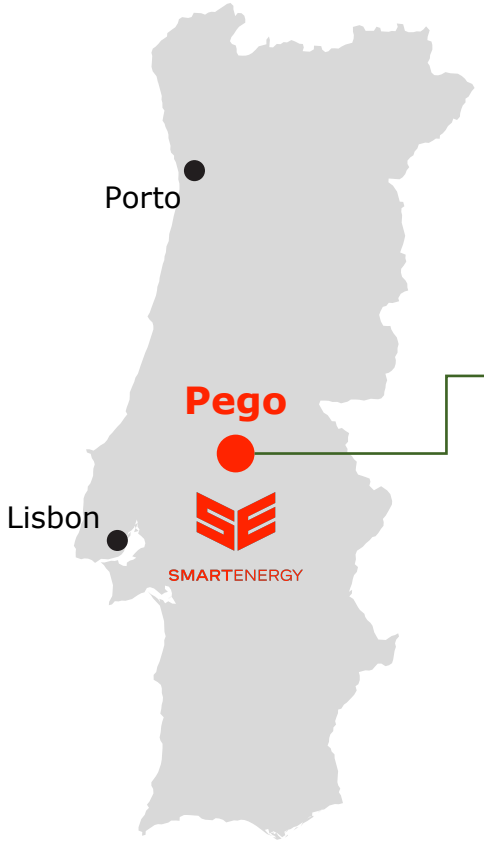
Additional information:

- Prior registration as gas producer at DGEG (licensing authority) has been obtained and the injection conditions are being discussed (dep. on reg.)
- Preliminary technical design study (with ThyssenKrupp) concluded

Source: SMARTENERGY Group AG

1) Project initially designed for offtake via nat. gas grid; other offtake models (e.g., mobility) conceivable if specific opportunities arise

Tagus project designed to achieve maximum efficiency through valley approach with co-location of RES, EL and off-take



Project to be located close to the existing power plant, in the vicinity of water source, gas and electricity grids (plot area 270 ha)

Water

Grid electr. (GO)

RES electricity

H_2 **Gas grid injection**

H_2 **Regional bus operat.**

H_2 **Industrial offtaker**

O_2 **Industrial offtaker**

Hea t **Industrial offtakers**

Split of H_2 offtake between multiple offtakers depending on required volume to ensure constant green H_2 offtake

Key success factor 1: Securing commercial offtake

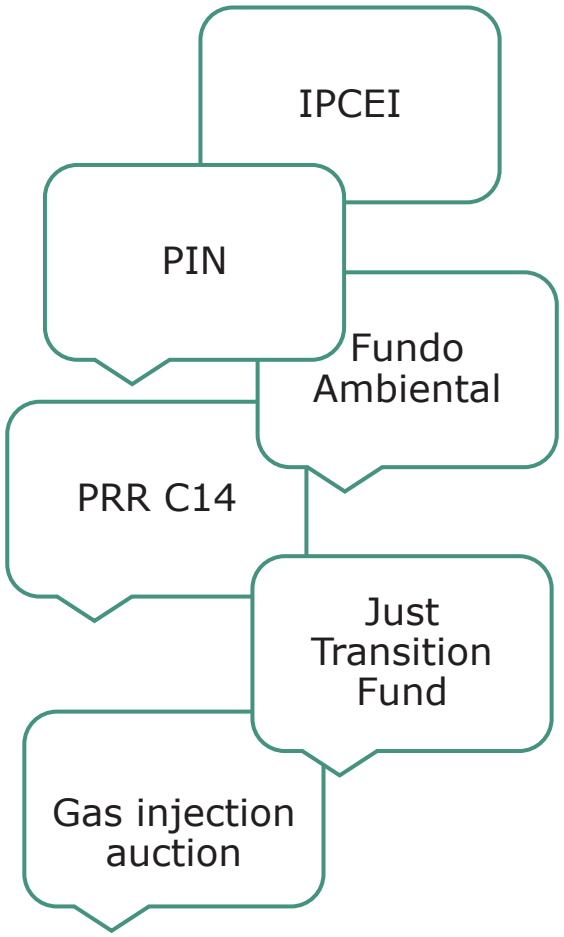
Key success factor 2: Access to tech. partners

Key success factor 3: Access to RES assets

Source: SMARTENERGY Group AG

Challenges for the early H2 movers to develop projects

Is the support sufficient for enabling the required market dynamics to scale up?



Challenges with H_2 project development for projects including as grid injection as off-take

Further technical development needed on equipment for industrial scale
- Blending and De-Blending Equipment
- Complementary "minor" equipment (measuring, odorization, etc.)

H2 pipeline infrastructures cost optimization needed
Experiences in Iberia:
- Pipeline cost by km
- Blending and injection cost

Technical regulations not yet completed
- Conditions of use, blending percentages, allowed H2 injection profile
- Conditions of use/installation for H2 transportation
- Control settings for H2 Injection and communication protocols

Accelerating the H2 market development in Portugal

What is needed to achieve the 2,5 GW from the developer perspective

Permitting	Regulation Stability	Bankability & Financing	Off-take	RES deployment
• Accelerate completion of legislation • Process applications timely (resources!)	• Update regulation to reflect new energy paradigms • Transparency on Incentives / Quotas / ETS / CO2 / Penalties	• Techno-economic viability • Financial programs for capital intensive transition projects	• Strategic approach / industry clusters • Market making mechanism / guarantees (supported by Gov)	• Dedicated development plan for RES for H2 (additionality requirement)

1 More Renewables fast dedicated to H2!

2 Support off-taking transition to Hydrogen

3 Support schemes need to meet investors expectations


Deployment led innovation – the momentum of real projects becomes the driving force for market players to join and accelerate innovation and economies of scale

Thank you!

Christian Pho Duc
CTO & Managing Director H_2 Projects

c.phoduc@smartenergy.net
+49 151 15001722

SMARTENERGY Group AG
Sihleggstrasse 17
8832 Wollerau SZ
Switzerland

www.smartenergy.net