SEAFUEL

Current hydrogen policy frameworks

Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION

Disclaimer

Coordinator of the edition: AREAM - Agência Regional da Energia e Ambiente da Região Autónoma da Madeira

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Contents

1. Introduction

Hydrogen is the most abundant chemical element in the Universe, containing the most energetic content per unit of weight. It is also less pollutant than other alternatives, since fuel cells produce electricity using hydrogen and only release water. However, hydrogen is not found naturally in its pure state, which means it has to be produced through chemical processes to be extracted.

This means that additional energy will be spent in this extraction, and pollutants will be released in these operations. Usually hydrogen is produced from natural gas, using a steam reforming process. At high temperatures (700 – 1100°C) and in the presence of a metal-based catalyst (nickel), steam reacts with methane to yield carbon monoxide and hydrogen. Additional hydrogen can be recovered by a lower-temperature gas-shift reaction with the carbon monoxide produced. Hydrogen can also be produced from water electrolysis.

Regarding the road transportation fuel, hydrogen is seen as a potential option. The main barrier to the widespread of the fuel among private vehicle owners is the production, transportation and refueling infrastructure. For this reason, the majority of demonstration projects are related

to the public bus sector, such as the Clean Urban Transport for Europe (CUTE), the Global Hydrogen Bus Platform (HyFLEET:CUTE), the Sustainable Transport Energy Programme (STEP) and the Ecological City Transport System (ECTOS).

However, some original equipment manufacturers (OEM) of light-duty vehicles have already engaged in alternative powertrain developing. The European Union has already implemented a pathway to increase research and development programs regarding renewable energy and energy efficiency, including hydrogen, and release a set of policy measures and incentives. In the present report, compile the SEAFUEL partners extensive search for their national policies regarding hydrogen and also the European Union policies.

2. Current Relevant Policy Measures and Incentives

2.1. Ireland's National policies

2.1.1. Hydrogen and Irish Renewable Electricity: Coping with Intermittency

Ireland has a target to achieve, by 2020, a 40% share of electricity generation from renewable sources. It has further targets to meet 12% of its national heating demand and 10% of its transport requirement from renewable sources. These targets are widely perceived as not being achievable by the date required. Indeed, they have been replaced by 2030 goals. However, achieving the renewably generated electricity portion of those targets are not as far off as for other sectors.

Wind energy, generated from 2,440 MW[1] of installed capacity at the end of 2015, accounted for 21% of total electricity generated in that year[2]. Hydro and other renewable electricity sources had a combined share of 4% of total electricity generation. Thus, the overall renewable electricity share was 25% at the end of 2015. Between start 2016 and August 2018 an additional 1,049 MW of wind generation have been added to the grid, bringing the total wind to 3,496 MW[3]. There have been no significant other renewables additions during the period. In 2017 approximately 29.6% of the electricity in the Republic of Ireland was generated by renewables[4]. Eirgrid, the national grid management body, estimate that a band of 3,900 – 4,400 MW of on-shore wind capacity is required to meet the 2020 RES-E targets for Ireland, with 4,200 MW being the most likely figure. If wind generation connections continue at the current rate (approximately 330MW per year), by the end of 2020, Ireland will be 4,156 MW, just short of 40% of its electricity wind generation[5] – this will be approximately at the 2020 targets.

Other renewable energy generation technologies are expected to start coming on-stream during 2019: approximately 842 MW of PV generation has passed through both planning and grid application process[6]. If, as is quite possible, this PV generation comes on stream before or in 2020, there will be a total of 4,998 MW (above 2020 targets).

Thus, the vast majority the renewable energy generation required by Ireland to meet its 2020 targets will be from non-dispatchable, intermittent sources. This is set to increase over time as Ireland commits to a greater share of renewable generation.

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[1] https://www.seai.ie/resources/publications/Irelands_Energy_Projections.pdf
[2] Implies a total generation capacity from all sources of 9,384MW
[3] http://www.eirgridgroup.com/site-files/library/EirGrid/Wind20Installed20Capacities.png
[4] http://www.eirgridgroup.com/site-files/library/EirGrid/Fuel20Mix.jpg
[5] http://www.eirgridgroup.com/site-files/library/EirGrid/Generation_Capacity_Statement_2018.pdf
[6] http://www.eirgridgroup.com/site-files/library/EirGrid/2018-Batch-(ECP-1)-Eligible-Applications-Joint-SO-Publication-31.8.18.pdf

Interconnection between Ireland and other countries (i.e. Britain) is at present limited to 1,000 MW. The East West Interconnector (EWIC) connecting Ireland and Wales, has the capacity to transport 500 MW. The Moyle Interconnector linking the electricity grids of Northern Ireland and Scotland, has a capacity of 500 MW. There are plans for another interconnector between Ireland and France of approximately 700 MW. Surplus dispatchable renewably generated power is cheap when in surplus. However, dispatchable power when energy is scarce (i.e. when there is less intermittent power available and demand is high) is expensive: thus, interconnection will more likely favour UK and France consumers of electricity even if it does Irish generators to upscale without over-constraining generation.

These two features of the Irish electricity supply (high intermittency and low interconnection) mean that Ireland may find itself relying far into the future on imported fossil fuel-powered dispatchable back-up generation capacity (using for example natural gas from Norway or Russia to power generators on standby), which are carbon emitting. Alternatively, it will need to build-out vastly more interconnection with its neighbours. It could in another scenario hope that the rapid uptake of electric vehicles could act as a distributed national 'battery' for converting excess intermittent generation into useable power. In yet another scenario it could also explore how to develop dispatchable non-carbon emitting generation technologies.

According to Eirgrid, in 2017, the total dispatch-down energy from wind generation in the Republic of Ireland was 277 GWh[7]. This is equivalent to 3.7% of total available wind energy here. Thus while there is currently a need to constrain wind generation, the excess capacity that is constrained and that could be diverted to generation of hydrogen was 277 GWh in 2017.

Hydrogen is a potential energy storage solution to this dispatchable power issue. The potential for Hydrogen within a renewable energy matrix has been studied in relation to Ireland, with mixed results.

Carton and Olabi (2010)[8] found that 'Hydrogen storage and efficient fuel cell utilisation is a possible answer to some of the current energy storage and delivery issues. Hydrogen and electricity together
represent one of the most promising ways to realise sustainable energy, and fuel cells provide the most effective device for converting hydrogen into electricity'. They pointed to technological and societal challenges as obstacles to this potential. These ranging from societal and public attitude issues. The relevance of policy maker attitudes to hydrogen are discussed below.

Connolly et al., (2011)[9] compared three scenarios: Biomass-based, hydrogen-based and electricity-based energy systems. They suggested that Hydrogen to Electricity where Hydrogen

[7] http://www.eirgridgroup.com/Annual-Renewable-Constraint-and-Curtailment-Report-2017-V1.pdf
[8] J.G. Carton, A.G. Olabi, 'Wind/hydrogen hybrid systems: Opportunity for Ireland's wind resource to provide consistent sustainable energy supply', *Energy*, Volume 35, Issue 12, 2010, Pages 4536-4544, http://www.sciencedirect.com/science/article/pii/S0360544210004895
[9] D. Connolly, H. Lund, B.V. Mathiesen, M. Leahy, 'The first step towards a 100% renewable energy-system for Ireland', *Applied Energy*, Volume 88, Issue 2, 2011, Pages 502-507, http://www.sciencedirect.com/science/article/pii/S030626191000070X

is produced by otherwise curtailed wind would be an expensive process involving much energy loss. They found that hydrogen produced by curtailed wind energy which is subsequently used as transport fuel is more efficient.

Truc et al (2017) [10] looked at combining Hydrogen produced from curtailed wind and combined with biomass generated CO2 as transport fuel. They found that there is potentially enough feedstock to produce the biogas required, but that there is frequently not enough surplus electricity.

Hanley, Dean, and ó Gallachóir (2018)[11] suggested that the significance of Hydrogen within the transition to fossil free energy network may only gradually emerge post 2030. However, one clear pathway towards greater significance for hydrogen is its greater use as a result of 'increased wind electricity in the power system in particular'. However, there is a role for hydrogen storage of intermittent wind electricity generation in areas where it would reduce the requirement for large scale grid re-enforcement, i.e. in remoter areas. It should be noted that much of Ireland wind resource is located in remoter Western parts of the country. Eirgrid's 'Grid West' project which sought to re-enforce the grid in North Connacht in the West of Ireland, to enable increased wind generation in the area and the subsequent transmission of large scale wind generated electricity was announced in 2012, but shelved in 2017. This was partly as a result of the scaling-back of a large wind farm by the national planning authority, An Bord Pleanála, in Co Mayo, but also in the face of considerable community and political opposition to the erecting of large electricity pylons Grid West necessitated.[12]

2.1.2. Ireland's national policies for hydrogen

There has been little policy development on a national level in relation to the possible hydrogenization of transport in Ireland.

The Irish Department of Transport's (DTTAS) latest policy document, *National Policy Framework Alternative Fuels Infrastructure For Transport In Ireland 2017 to 2030*, DTTAS, 2017[13], says that

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[10] Truc T.Q. Vo, Ao Xia, David M. Wall, Jerry D. Murphy, 'Use of surplus wind electricity in Ireland to produce compressed renewable gaseous transport fuel through biological power to gas systems', *Renewable Energy*,
Volume 105, 2017, http://www.sciencedirect.com/science/article/pii/S0960148116311491
[11] Emma S. Hanley, JP Deane, BP Ó Gallachóir, 'The role of hydrogen in low carbon energy futures–A review of existing perspectives', *Renewable and Sustainable Energy Reviews*, Volume 82, Part 3, 2018, Pages 3027-3045, http://www.sciencedirect.com/science/article/pii/S1364032117314089

[12] https://www.irishtimes.com/news/environment/mixed-reaction-to-scaling-back-of-240m-grid-west-project-1.3230977
[13] http://www.dttas.ie/sites/default/files/publications/public-transport/english/npf-picture/6186npfalternative-fuelsengv5.pdf

> *'Post-2030, it is likely that hydrogen will increase its penetration across the entire fleet spectrum with a correlated decline in the predominance of vehicles run solely on fossil fuels. It is Ireland's ambition that all new cars and vans sold in this country from 2030 will be zero emission (or zero emission-capable). The freight and bus sectors will continue on a positive trajectory towards full penetration of low emissions vehicles (LEVs).'*

However, for the medium term, i.e. prior to 2030, the Irish government expects electrification of the national transport fleet to be more significant, with some biofuel technology complimented by LNG also expected to feature.

> *'Biofuels will continue to play a key role over the coming years and natural gas, along with some electrification, will provide an interim alternative solution for larger vehicles, i.e. freight and buses where significant reductions in CO2 could be expected from integrating biomethane with CNG/ LNG. LNG and methanol are likely to increase their penetration as fuels in the shipping sector.'*

The Biofuels Obligations Scheme[14] places an obligation on suppliers of mineral oil to ensure that 8.695% (by volume) of the motor fuel (generally gasoline and motor diesel) they place on the market in Ireland is produced from renewable sources, e.g. ethanol and biodiesel. It is presumed that ethanol and biodiesel as an additive to petrol and diesel offers Irish policy-makers a more straightforward means of reaching 2020 targets of 10% of transport energy being met from renewable sources.

Hydrogen was not expected by the department to deliver mass-market uptake between 2017 and 2030 as it believed the costs of the refuelling infrastructure (which it estimated as costing €800,000 each) and associated vehicles, are likely to remain prohibitive until the middle of the next decade.

2.1.2.1. Freight

The policy proposals outlined in the report were that while Hydrogen was considered versatile and suited to use in freight, and while there were arguments for further investigation of hydrogen as a freight transport fuel, there was a feeling that there was no current market in Ireland.

Transition to a hydrogen-based transport system would involve 'massive technological change and economic investment by consumers'. Ireland's unusual driving environment where right-hand drive vehicles predominate was cited as likely to slow-down the adoption of hydrogen freight vehicles. The report felt that Ireland would be 'unlikely to see a range of right-hand drive affordable hydrogen trucks coming onto the Irish market for some years to come'. The report took the position, that investing in costly infrastructure ahead of the market would be a high-risk strategy and could lead to early infrastructure becoming obsolete as the technology

[14] http://www.nora.ie/biofuels-obligation-scheme.141.html

advanced. In short, Ireland would let other countries take the lead in technology development and adoption, and would then follow when the case was proven. This is not an uncommon strategy for policy-makers in Ireland. In renewable generation for example, Ireland did not take the early adopter approach of set Feed in Tariffs per MWh/Kwh generated to stimulate renewables generation in the manner of the UK, Germany or France. Now likely to meet it's 2020 targets, it appears that policy-makers may feel vindicated in taking a 'wait and see approach'. That Ireland will not meet its renewable transport and renewable heat targets – and thus faces fines for failing to do so – could however be given as a counter-example.

2.1.2.2. Shipping

The DTTAS policy document suggested that fuels such as LNG and methanol, rather than hydrogen, were promising alternatives in the shipping sector. Particularly if they were to be used alongside a biofuel counterpart, such as biomethane or bio-methanol. However, here again, the policy took a sanguine view of new technologies and cautioned against 'investing in costly infrastructure too far ahead of the market'. There was no discussion of the experiences of BIG HIT and other hydrogen-fuelled shipping research projects.

2.1.2.3. Buses

There was some treatment of innovation in relation to hydrogen in the bus fleet. The reported acknowledged that, a hydrogen fuelled buses have been introduced to European fleets in recent years, but did not go into detail on this. While the feeling was that this demonstrated the potential of Hydrogen to meet real-life operation demands, the long-term commercial feasibility was still being examined. It felt instead that CNG was a more mature technology and could offer some improved air quality benefits especially where older buses are being replaced.

2.1.2.4. Private Cars

On the whole, there was very little examination of hydrogen in the DTTAS' policy document. It reflects a general sense at policy level that hydrogen is an nascent technology and that Ireland should await developments elsewhere before committing tax-payer support for Research and Development, let alone supporting a hydrogen refuelling network. The Sustainable Energy of Ireland is charged with informing and supporting government policy in the area of sustainable energy. In the area of transport, it has worked to promote the adoption of electric vehicles[15] within the context of increased presence of renewables on the grid. It would therefore be reasonable to presume that increased adoption of electric vehicles for private and small commercial transport, has been the accepted model for the decarbonisation of the transport sector in Ireland. The former Minster for Communications, Climate Action and Environment (DCCAE), Denis Naughten T.D., said this year:

> *'I would like to see a greater uptake and not just by private car owners but in the public sector as well. I am encouraging the Office of Government*

[15] https://www.seai.ie/news-and-media/drivingelectric-campaign-launched/

Procurement to actively engage and advise the public sector on the use of electric vehicles across all areas.'

However, it should be noted that policy makers are open to new approaches. Minister Naughten also has said he was open to the potential of hydrogen powered cars after examining them first hand and he made a series of videos on social media to mark the event.[16]

2.1.2.5. Hydrogen and the Climate Action Fund 2018 - Policy and Practice:

The policies outlined above are supported by recent funding decisions under the Irish government's Climate Action Fund[17]. This is a fund established under the National Development Plan 2018-2027 as part of Project Ireland 2040. The fund supports initiatives contributing to the meeting Ireland's climate and energy targets. The first call[18] awarded €10m (13% of the fund), towards an EV fast charger network extension, €8.5m (11% of the fund),

[16] http://www.nweurope.eu/media/4096/gencomm-h2go-news-june2018.pdf
[17] https://www.dccae.gov.ie/en-ie/climate-action/topics/climate-action-fund/Pages/default.aspx
[18] https://www.dccae.gov.ie/en-ie/climate-action/topics/climate-action-fund/call-for-applications/first-call-2018/project-assessments/Pages/default.aspx

towards an agri-biogas project[19], and €15 (19.5% of the fund), towards the hybridisation[20] of the rail stock. This would appear to indicate that the policies outlined above are being supported by financial aid decisions.

It should be noted that Ireland's 'wait and see' approach is in contrast to that of our nearest neighbours. In Scotland there is active research into Hydrogen in weak grid locations as an answer to the constraint of intermittent renewables (i.e. BIG HIT in Orkney[21]). There is also an active pilot of hydrogen in transport (with a fleet of ten buses) in Aberdeen[22]. The UK's Committee on Climate Change is quite clear about the necessity of engaging early on in the development of hydrogen technologies in a variety contexts.[23]

> *'Deployment of hydrogen should start in a 'low-regrets' way over the next decade, recognising that even an imperfect roll-out is likely to be better in the long term than a 'wait-and-see' approach that fails to develop the option properly.'* (UK Committee on Climate Change, *Hydrogen in a low-carbon economy*, 2018, p7)

2.1.3. Implications for SEAFUEL

There is in Ireland great interest in the opportunities for innovative solutions to intermittent generation constraint issues from researches and technology developers. In parallel to SEAFUEL, GENCOMM, an INTERREG funded multi-national study into 'Smart Hydrogen', is examining this very issue. There is also research being conducted into improved electrolyser techniques in Trinity (CRANN) and elsewhere. However, there is, as yet, only very few hydrogen-fuelled passenger cars on the island of Ireland[24]. But there is nowhere here to refuel them.

There are significant policy obstacles to overcome and much work demonstrating the potential importance of hydrogen in the mix of technologies that will deployed to aid in the transition to the carbon fuelled society here.

SEAFUEL can be expected to play a central role in taking the first steps in overcoming these policy obstacles in Ireland. In parallel to GECOMMs more island-wide approach, SEAFUEL can demonstrate hydrogen's value in certain critical regional contexts: remoter areas, not connected to the national gas network; areas where a less developed electricity grid is a constraining factor on intermittent renewable generation role out; areas where there are currently expensive but crucial transport technologies in use – such as shipping.

[19] Biogas injected into the national natural gas grid
[20] Battery and diesel hybrids
[21] https://www.bighit.eu/about/
[22] http://www.all-energy.co.uk/__novadocuments/30431?v=635060505159530000
[23] https://www.theccc.org.uk/wp-content/uploads/2018/11/Hydrogen-in-a-low-carbon-economy.pdf
[24] https://www.irishtimes.com/news/environment/hydrogen-fuelled-toyota-mirai-takes-to-irish-roads-1.3230333

Following in from the approach advocated by the UK's Committee on Climate Change, these contexts could offer 'low-regrets' opportunities. Replacing expensively fuelled, high carbon emitting diesel ferries with locally generated (and owned?) clean power in a tourist-friendly using a sustainability centred technology could serve as an excellent public acceptance driver. Providing alternative uses for electricity at times where grid constraints would often apply (where the grid is weakest) could help strengthen not only the business case for renewable generation in those areas. It could also reduce levels of public opposition to grid re-enforcement that can beset these projects in remote, often scenic areas.

Finally, looking to replace the more expensive home heating fuels (kerosene and bottled gas[25]) in areas where there is no natural gas network, will enable hydrogen to develop cost-effectiveness and resource efficiency on better terms than if it measured itself against a historically subsidised natural gas alternative. Each of these scenarios are 'low-regret' in that while they require innovation and some small technology switch risks, would be introduced where there are significant difficulties already.

[25] https://www.seai.ie/resources/publications/Domestic-Fuel-Cost-Comparison.pdf

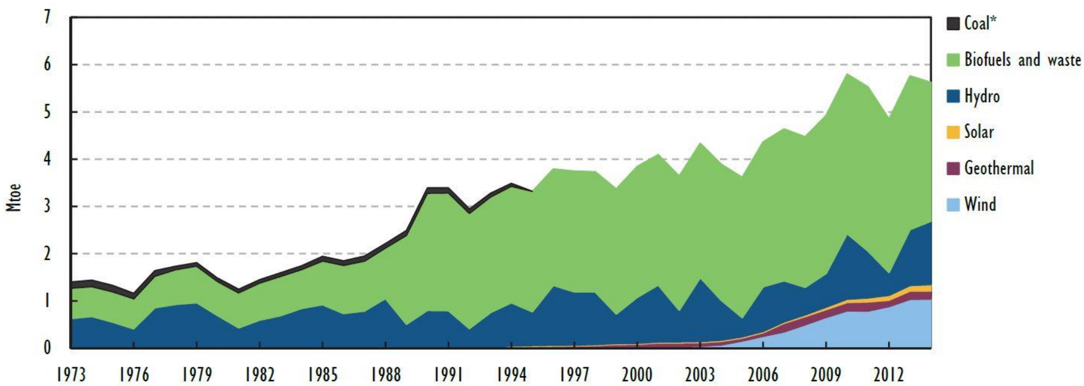
2.2. Portugal's National policies

Portugal is geographically situated on the west coast of continental Europe, in the Iberian Peninsula. It borders Spain to the north and east, and the Atlantic Ocean to the west and south. Major population centres include Lisbon, the capital city, Porto, Braga and Coimbra. In addition to the continental territory, Portugal includes the two autonomous regions located in the Atlantic Ocean, the islands of the Azores located to the west and Madeira to the southwest. Portugal covers a total area of 92 212 square kilometres and has a population of 10.31 million inhabitants.

Overview of the current energy mix

- **Supply**

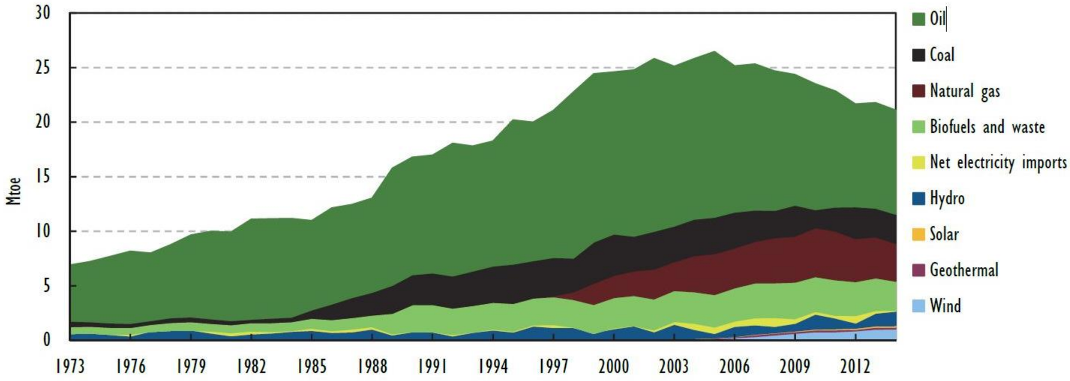
Portugal's dependence on imported energy has been historically high since the country does not produce oil or natural gas. However, due to an increasing amount of renewable energy in the generation mix, total energy dependence has been declining.
Portugal produced 5.6 million tonnes of oil-equivalent (Mtoe) of energy in 2014. Energy is produced from renewables, which makes total production volatile year on year (Figure 1). Production averaged 5.0 Mtoe over the ten years to 2014.
In 2014, energy was produced from biofuels and waste (52.2%), hydro (23.9%), wind (18.5%), geothermal (3.1%) and solar (2.3%). Portugal has no fossil fuel production (including coal, oil and natural gas). Wind, solar, geothermal, and biofuels and waste increased at an annualised rate of 31%, 20%, 8.4% and 0.2%, respectively during 2013-14.
Hydro production is volatile year on year and was 4.7% higher in 2014 than in 2004. The boom of wind and solar power has been the main driver in growing energy production in Portugal. In 2014, total production was 44.4% higher than in 2004.



Note: estimated for 2014.
* Coal production ceased in 1994.

Figure 1 Energy production by source from 1973-2014

Portugal's total primary energy supply (TPES) was 21.1 Mtoe in 2014. It was 18.3% lower, to 25.1 Mtoe, in 2003 with a peak of 26.5 Mtoe in 2005 (Figure 2). The Portuguese government projects that demand will return in the coming years and TPES will be 13.5% higher in 2020 than in 2014.



Note: estimated for 2014.

* Negligible.

Figure 2 TPES from 1973-2014

Fossil fuels accounted for 74.3% of TPES in 2014, including oil (45.1%), natural gas (16.4%) and coal (12.7%). Renewables accounted for 25.4%, including biofuels and waste 12.6%, hydro 6.4%, wind 4.9%, geothermal 0.8% and solar 0.6%. The remaining 0.4% was accounted for by net electricity imports. In the ten years to 2014, the use of oil and coal has contracted by 35.3% and 20.4%, while natural gas supply grew by 5%. Gas supply boomed in the ten years to 2010 when it peaked at 4.5 Mtoe (120% higher than in 2000). The boom in wind power has led to an increase in its share in TPES, up from less than 0.1% in 2004 to 4.9% in 2014.

Portugal relies on imports of fossil fuels for most of its energy needs as domestic energy production accounts for around 27% of TPES. During 2014, Portugal imported 15.2 Mtoe of crude oil and oil products and exported 4.6 Mtoe. Net imports of oil and oil products have declined by 32.7% compared to 2004. Natural gas imports amounted to 3.5 Mtoe in 2014 which is 5.1% higher than in 2004. Coal imports were 2.6 Mtoe, down from 3.2 Mtoe ten years earlier.

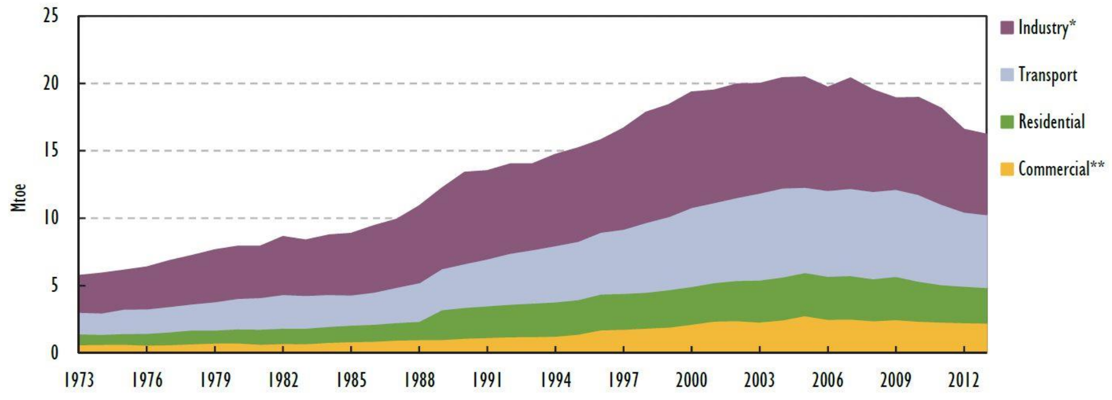
- ## Demand

Energy consumption is rising steadily around the world, fuelled by the earth's expanding population and growing industrialisation in emerging economies. At the same time, pressure to mitigate the effects of climate change and conserve fossil fuel reserves is mounting. Society is challenged to balance these conflicting demands by decarbonising our energy chain and finding a clean, viable source of fuel for the expanding road transport/mobility sector.

Portugal's total final consumption (TFC) amounted to 16.2 Mtoe in 2013. TFC represents around 75% of TPES, with the remainder used in power generation and other energy industries. TFC has declined by 18.9% from 2003 to 2013, peaking at 20.5 Mtoe in 2005 (Figure 3).

Industry and transport are the largest consuming sectors with 36.7% and 33.3% of TFC in 2013, respectively. The residential sector represented 16.3% while the commercial and other services sector (including agriculture and fisheries) had the smallest share of 13.7%.

Transport demand declined by 16.2% over the same period, albeit its share in TFC increased from 32.3% in 2003. The residential and commercial sectors decreased consumption by 15.3% and 3.5%, respectively.



* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Figure 3 TFC from 1973 to 2012

2.2.1. Portugal's national policies for hydrogen

Portugal's greenhouse gas (GHG) targets (including for the second Kyoto commitment period) are derived from the European Union's 2020 targets. As a result of the effort sharing of the Union's GHG target of -20% from 2005 to 2020, Portugal will have to limit the growth of emissions from the sectors outside the European Union Emissions Trading Scheme (EU-ETS) to 1.0% above its 2005 levels by 2020. In preparation for COP21 in Paris in December 2015, participating countries agreed to publicly outline what post-2020 climate actions they intend to take under the international agreement, known as their Intended Nationally Determined Contributions (INDCs). The EU and its Member States, including Portugal, are committed to a binding target of at least a 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990, to be fulfilled jointly. Emissions reductions below 2005 levels would be 43% in the EU-ETS sector and 30% in the non-ETS sector. The level of effort to be made by each member state to achieve this EU target has not yet been decided. By 2050, the European Union is aiming to reduce GHG emissions by 80% to 95% below their level in 1990.

In the 2013-20 phase, Portugal will receive revenue from auctioning allowances. Decree Law 38/ 2013 which transposed Directive 2009/29/EC into national law, established that 100% of auction revenues shall be used to support the Portuguese Carbon Fund. This money will be used to support climate policy, further stating an indicative allocation (mitigation, adaptation, R&D and co-operation with developing countries) of the revenues that are not directly allocated to the compensation for the additional costs of renewable energy, including that 30% of those revenues should be used in financing adaptation policy.

This includes the implementation of the National Climate Change Adaptation Strategy (ENAAC), including adaptation and co-financing programmes under the Multiannual Financial Framework 2014-20.

- **Commitment for Green Growth**

Portugal has recently launched an ambitious long-term commitment – the Commitment for Green Growth – establishing goals and initiatives on green jobs, resource productivity, energy efficiency, sustainable mobility, spatial planning, forest management, water resource efficiency, air and water quality, and biodiversity. It also sets the target of reducing GHG emissions by 30% to 40% until 2030 below 2005 levels and to increase renewable energy share to 40% by 2030.

The Commitment for Green Growth seeks to lay the foundations for a commitment to policies, goals and targets that foster a development model that will reconcile essential economic growth with lower consumption of natural resources, social justice and quality of life for the population.

- ### Green taxation reform

The purpose of the Green Taxation Reform is to stimulate innovation and sustainable growth, help to reconcile protection of the environment with economic growth, while remaining consistent with the general principles and goals of environmental policy, especially those set out in national and EU guidelines and standards. The reform must also encourage the efficient use of resources, thereby preserving and harnessing natural capital and fostering fair and sustainable use of the soil, territory and urban areas while introducing signs which facilitate the transition to a low-carbon economy.

Under the principle of fiscal neutrality, the net income from the green taxation reform will be allocated to the reduction of personal income taxes. Importantly, it includes a carbon tax, indexed to the price of carbon permits in the EU-ETS which aim to achieve more effective consumption decisions and to promote a low-carbon economy that is inclusive, competitive and innovative, and which will be more efficient in the use of resources, particularly energy. It also includes incentives to electric vehicles, biodiversity and sustainable mobility.

- ### The Portuguese Carbon Fund

The Portuguese Carbon Fund (FPC), established by law in 2006 under the Ministry for Environment, Spatial Planning and Energy, is a financial instrument for acting on the carbon market to ensure compliance with national targets on climate change, making use of the flexibility mechanisms of the Kyoto Protocol and supporting national projects to reduce emissions.

The FPC has also created a Support Projects Programme to support projects or groups of projects on the national territory that could lead to reductions/ removals of GHG emissions under the Kyoto Protocol.

The FPC obtains emission credits generated under the flexible mechanisms under the Kyoto Protocol: clean development mechanism; joint implementation of projects; and international emissions trading.

The potential for reducing CO_2 emissions associated with the Program for Electric Mobility in Portugal supported by this fund is estimated at 920 334 tCO_2 by 2020.

- ### National Low Carbon Roadmap

The National Low Carbon Roadmap (RNBC) aims to determine a set of paths for cost effective emissions reductions (for long-term targets concerning the national GHG emissions reduction) and its subsequent policy options, taking into account the national contribution to the EU target for 2050 (work completed in 2012).

- **Strategic framework and national programme for Climate Change for 2013 – 2030**

The National Programme for Climate Change for the period 2013-30 (PNAC 2020/2030): identifies policy options, measures and instruments for a trajectory established by the Green Growth Commitment adopted by the government in early 2015, compatible with the 2020 and 2030 EU emissions reduction targets. It identified sectoral responsibilities, funding and monitoring and control mechanisms.

The Strategic Framework:

- aims to ensure a stable investment environment to allow for the development of sustainable low-carbon technologies
- acknowledges the role of carbon markets and the EU Emissions Trading Scheme (EU-ETS) as essential tools for achieving efficient and cost-effective emissions reductions
- aims to ensure that the potential of land use, land-use change and forestry (LULUCF) is recognized and promoted at national and international levels
- aims to promote mainstreaming of climate policy goals, in terms of both adaptation and mitigation, in the relevant sectoral policies.

2.2.2. Portugal's national policies for hydrogen

Since the late twentieth century, the hydrogen economy and technology has earned the interest of the European Union. The strategic vision of the contribution of hydrogen to a sustainable energy system, following the Kyoto Convention, gains expression in the 7th Framework Programme (2007-2013), with the creation of the first community Joint Technology Initiative (JTI) – FCH-JU (Fuel Cells and Hydrogen/Joint Undertaken)-, a partnership between industry, the scientific and technological system and the European Community. According to José João Campos Rodrigues, President of the Directorate of AP2H2 – Portuguese Association for the promotion of hydrogen, this partnership remained and was even reinforced in Horizon2020.

After an initial phase, which focused on the development and optimization of technology, simultaneously with its demonstration and testing in concrete applications (namely urban public transport), currently the goal is to create and develop the market, investing in strength in the establishment of a network of service stations and fleets already with market expression. The responsible is that the European builders are already preparing the launch of the first commercial pre-series until 2020, following the projects of Toyota, Hyundai and Honda, with commercial solutions already available.

Torres Vedras Municipality (Portugal) has signed the Memorandum of understanding on the Hydrogen Regions and Cities Initiative in 2017 according to Fuel Cells and Hydrogen Joint Undertaking (FCH JU) and has been promoting hydrogen as an important energy vector for the decarbonization of the territory. Figure 5 shows the integration of this Municipality in the MoU and all the regions involved. The Torres Vedras Municipality is also member of HyEr – Association for Hydrogen and fuel cells and Electro-mobility in European Regions.

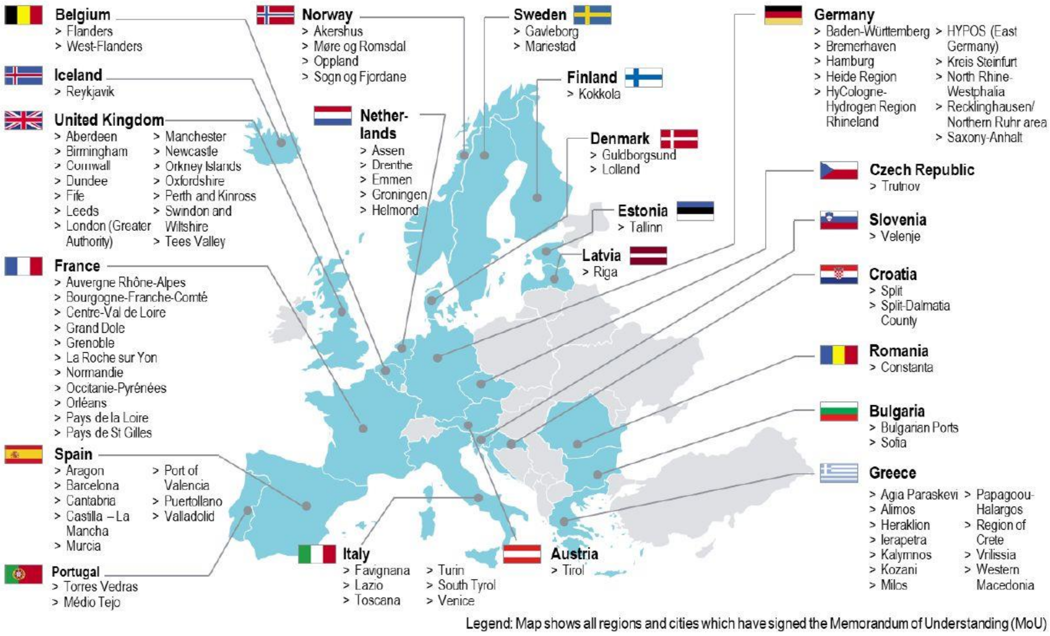


Figure 4 Overview of participating regions and cities as of May 2018 which have signed the MoU in FCH-JU.

Portuguese company of Salvador Caetano Indústria dedicated to the development and manufacture of buses, take another significant step in the development of solutions for the collective transport of passengers with zero emissions.
For the first time in Europe, Toyota will provide its fuel cell systems, hydrogen tanks and other key components to Caetanobus, which will produce and market buses. With this partnership, Toyota reinforces its contribution to the creation of a hydrogen-based society, promoting fuel cell technology applied to other means of transport than just passenger cars.
The first zero-emission fuel cell buses will begin to leave the Portuguese CaetanoBus lines at the end of 2019 and be provided to European operators.

Figure 5 Fuel Cell Bus

In this context, "keeping alive the flag of hydrogen" was not an easy task for AP2H2, established in 2003, following the participation of the STCP in the CUTE project demonstration and testing of urban hydrogen buses. These were the first assertions of the national community to consider hydrogen an energy-sustainable solution.

Currently, AP2H2 has been underway in its action plan, the H2SE project, supported by SIAC2020, in partnership with the INEGI and the IPP-Instituto Politécnico de Portalegre, which represents an investment in study, promotion and dissemination in the amount of 270,000 euros up to 2018.
The elaboration of a road map that evaluates the conditions of entry of hydrogen into the energy basket up to 2050 is one of the initiatives underway.

- **Portuguese Legislation Framework**

H2 is an essential solution for the viability of a 100% renewable energy system, the truth is that its realization implies strong investments in infrastructure and pilot initiatives and demonstration that allow hydrogen to assert itself as a competitive solution.
The current Portuguese legislation applied complies Decree-Law No. 60/2017 of 9th of June establishing the framework for the implementation of an infrastructure for alternative fuels, transposing Directive No. 2014/94/EU of 22nd of October about the establishment of a fuel infrastructure for the energy transition in the transport sector including hydrogen as an alternative fuel. Directive No 2009/28/EC of the European Parliament from 23rd of April about the promotion of the use of energy from renewable sources has defined a specific objective, common to all Member States, of incorporating 10% of renewable energy in transport fuels.
The EU Parliament Environment Committee on October 18, 2018 approved for the first time in history a legally binding 35% cut in carbon dioxide emissions from new trucks by 2030, responsible for 25% of the EU's transport emissions. The Committee also backed a surprising intermediate target of 20% by 2025.
In addition, a mandate will be introduced for zero and low-emission trucks of 5% by 2025 and 20% by 2030, excluding trucks running on natural gas. Urban buses will see a higher mandate of 50% by 2025 and 75% by 2030 for which only fuel cell and battery powered buses will meet this target.
After the successful declaration of the Hydrogen Initiative signed by 25 European Energy ministers, this September 2018, Energy ministers and government officials from around 20 countries on October 23, 2018, in the first Hydrogen Energy Ministerial ever, indicated in their Tokyo Statement that they will step up cooperation in promoting the use of hydrogen as an alternative energy source by sharing technology and standards. Participants also stressed the need to jointly analyze the effectiveness of hydrogen use in reducing carbon dioxide emissions as the world grapples with climate change. Portugal is included in the Hydrogen Initiative.

2.2.3. Autonomous Region of Madeira's policies for hydrogen

Hydrogen as an energy carrier and its use in passenger transportation through the fuel cell technology is widely considered as part of the solution to help meeting the targets. Hydrogen vehicles may include vehicles with internal combustion engines, but for the longer-term fuel cell powered vehicles are expected to prevail. Due to be a zero-emission technology, the need for a methodology on how to account for Greenhouse Gases (GHG) intensity of energy carriers and determining appropriate metrics is essential to make sure that post 2020 targets provide the right incentives to manufacturers and energy suppliers. For this reason, in order to make a pathway and contribute to a safe, efficient and prosperous solution in the long run for the development of an accurate policy for hydrogen in Madeira Autonomous Region it essential to develop a hydrogen roadmap starting to:

- Promote and disseminate the economy and technology of hydrogen;
- To help the hydrogen economy integrate regional agendas of economy, energy and sustainability;
- Disseminate regional competences and promote actions aimed at developing regional scientific and technological competences related to hydrogen;
- Support actions aimed at the contribution of hydrogen to regional economic development;
- Promote and support the participation of entities in European projects for the development and testing of hydrogen technologies;
- Promote the formation of frameworks and the literacy of the public with regard to the potentialities and opportunities of the hydrogen economy and technologies in the feasibility of a new sustainable energy paradigm;
- Promote and collaborate in the drafting of legislation, regulations, codes and standards necessary for the safe use of hydrogen in its various applications.

Hydrogen is becoming more common as a low carbon fuel for transport. This is because hydrogen as a low carbon transport fuel has zero tail-pipe emissions, helping towards cleaner air, particularly in urban areas.
Hydrogen buses are already on the road in London and Aberdeen. Hydrogen fuel cell cars are becoming ever more popular, and hydrogen fuel cell trains are under development for trials around the world and in the North West of England.
Government additional funding to support the development of hydrogen for transport until 2020 and more substantial sources of hydrogen, along with a pipe network could be key drivers for a substantial growth in the use of hydrogen for transport.

2.2.4. Other hydrogen projects in Portugal

Hydrogen related projects in Portugal:

- **Demonstration:**
  CUTE
  Virtual Guel Cell

- **Policy**

HySociety
HyNet
HyWays
HyCo

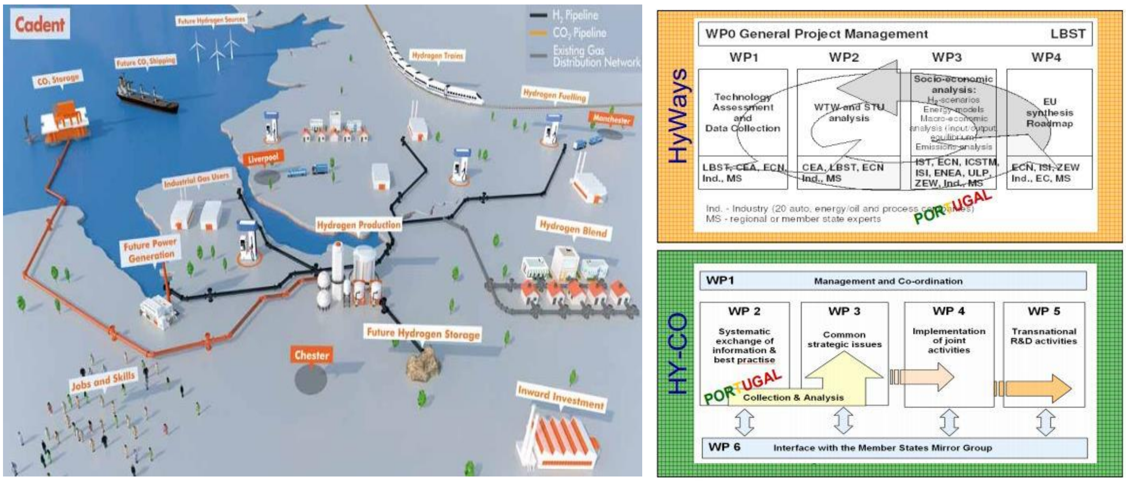


Figure 6 Example of Hydrogen Projects

- **Some National H2 related projects**

  Technology Platform
  H2REM
  Promotion & Dissemination of H in PT
  Green Hotel
  Hi-Po
  EDEN
  Transnational call (HY-CO) with DK, NL, SL, FR & PT
  HyER members
  FCH JU -Fuel Cells and Hydrogen Joint Undertaking: BeingEnergy Project

2.3. Spain's National policies

2.3.1. Introduction

Tenerife is the largest and most populated island of the seven Canary Islands. It is also the most populated island of Spain, with a land area of 2,034.38 square kilometers (785 sq mi) and 898,680 inhabitants, 43 percent of the total population of the Canary Islands. Tenerife is the largest and most populous island of Macaronesia. The capital of the island, Santa Cruz de Tenerife, is also the seat of the island council (Cabildo Insular).

Approximately five million tourists visit Tenerife each year, the most visited island of the archipelago. It is one of the most important tourist destinations in Spain and the world.

The electric power system of the Canary Islands is made up of six small-sized electrically isolated systems and a network of electricity infrastructure that is weakly meshed. These conditions make these systems less stable and secure than large interconnected systems in which it is possible to guarantee supply at times when peaks in demand occur or when faced with certain situations in which there is a lack of generation. To reduce the vulnerability of these electrically isolated systems it is key to incorporate energy storage systems, whose main purpose is security of supply and system security and facilitates the integration of non-manageable renewable generation. Similarly, it is essential to develop new interconnections between islands that allow mutual support between systems and help improve the meshing of the grid in order to have alternative supply paths in case of incidents.

The Canary Island's electric power system is evolving towards a new energy model, based on renewable energies, that is more efficient and sustainable. The aim is that these locally-available renewable energy technologies, which produce zero CO2 emissions, achieve a greater presence in the coverage of the Islands' electricity demand and replace other energy technologies based on more expensive and polluting fossil fuels.

The state of art of the hydrogen vehicles up to 2016 in Spain is included in the **National Framework for Alternative Energy in Transportation**.

FLEET OF HYDROGEN POWERED VEHICLES

The Spanish fleet of vehicles powered by hydrogen is limited to demonstration projects (The principal demonstration projects carried out; CUTE, ECTOS, HyChain, Hércules, Delfín and ExpoAgua) , of which 11 vehicles were authorised to circulate on public roads in June 2016 according to data from the DGT.

Table III-28. Development of fleet of hydrogen-powered vehicles (December 2012-June 2016)

HYDROGEN FLEET	2012	2013	2014	2015	2016 (until June)
Lorries to 3500 kg	0	0	1	0	0
Vans	0	0	1	0	0
Motorcycles	0	0	1	0	0
Cars	1	2	2	2	3
Others	0	0	33	8	8
Total	**1**	**2**	**38**	**10**	**11**

Source: DGT from data existing in June 2016.

EXISTING REFUELLING INFRASTRUCTURE

Spain has six hydrogen plants in different operating states whose locations and technical characteristics are given in the following tables.

Table III-29. Existing hydrogen refuelling stations in June 2016

AC	LOCATION	OPENING YEAR	TYPE ACCESS	STATION OPERATOR
Andalusia	Sanlúcar la Mayor (Sevilla)	2010	Accessible to the public	Abengoa
	Puerto de Sevilla (Sevilla)	2015	Accessible to the public	Abengoa
Aragon	Valderespartera (Zaragoza)	2008	Restricted use	Expo Zaragoza Empresarial, SA
	Walqa Technology Park Ctra Zaragoza-Huesca 75 km (Huesca)	2010	Accessible to the public	Aragon Hydrogen Foundation
Castile la Mancha	La Torrecica (Albacete)	2012		AJUSA
	Puertollano (Ciudad Real)	2016	Accessible to the public	CNH 2

Source: AeH2.

Table III-30. Technical characteristics of existing hydrogen refuelling stations in June 2016

LOCATION	OUTFITTED FOR CARS	OUTFITTED FOR BUSES	OUTFITTED FOR OTHER VEHICLES	NO. REFUELLING POINTS	TYPE H_2 PRODUCTION	SOURCE OF H_2	DELIVERY FORM	PRESSURE [118] (BARS)
Sanlúcar la Mayor (Sevilla)	Yes	Yes	Yes	1	It supports supply under pressure, but has production 'in situ' using renewable electrolysis	Renewable electrolysis	Under pressure	350
Puerto de Sevilla (Sevilla)	Yes	Yes	Yes	1	It supports supply pressure, but has production 'in situ' using renewable electrolysis	Renewable electrolysis	Under pressure	350
Valderespartera (Zaragoza)	Yes	Yes	Yes	2	Supplier and in situ production.		Under pressure	200-350
Walqa Technology Park (Huesca)	Yes	Yes	Yes	2	In situ production from solar/wind energy through electrolysis	Renewable electrolysis	Under pressure	200-350
La Torrecica (Albacete)	Yes	Yes			Supplier and in situ production.			350
Puertollano (Ciudad Real)	Yes	Do not	according tank	1	In situ production from solar energy through	Solar	Under pressure	350
					electrolysis			

Source: AeH2.

Although Hydrogen can help in the energy transition in the Canary Islands as so recognizes *The Energetic Strategy of the Canary Islands 2015-2025* and *the Intelligent Specialization Strategy of the Canary Islands (2014-2020)*, today there is no national and/ or regional specific actions taking place to strengthen and facilitate the implementation of Hydrogen as an alternative fuel source.

2.3.2. Current Relevant Policy Measures and Incentives

The specific measures to implement the Strategy to Promote Alternative Energy Vehicles are included in the National Framework for Alternative Energy in Transportation, and is divided in three priority areas (market, infrastructure and industrial promotion). Although the information is in ANEX , please find the information below.

In order to implement the Strategy to Promote Alternative Energy Vehicles through specific measures, three Priority Areas have been defined:

- Area I. -Market. Actions to drive demand to facilitate increased supply and economies of scale.

- Area II. -Infrastructure. Actions to promote a network infrastructure to meet the mobility needs of users.
- Area III. –Industrial production. Actions to promote the industrial production of alternative energy vehicles and the associated supply points, with the aim of placing Spain at the forefront of driving these technologies.

The above three areas have in common the Crosscutting Priority. - Regulatory Framework under which the established rules and tax incentives give continuity and stability to all the actions, making it possible to provide certainty to the market, to investors in infrastructure and to industry leaders. Within the Priority Areas, six specific action areas have been defined:

In Area I. -Market.

- Area I: Acquisition of Vehicles with Alternative Energies.
- Area II: Dissemination and awareness of alternative energy.

In Area II. -Infrastructure.

- Area III: Refuelling Infrastructure.

In Area III. Industrial production.

- Area IV: Promoting Industrial production and RDI

In the Regulatory Framework crosscutting priority

- Area V: Regulations
- Area VI: Tax Incentives

In total, there are 38 Promotional Measures developed at state level, to promote the use of alternative energy in road transport. Their relation to the priority areas and areas of operation are set out below.

MARKET	**ACQUISITION OF VEHICLES WITH ALTERNATIVE ENERGY SOURCES**	
	MK-1	MOVEA-Acquisition Plan
	MK-2	Convention for improvement in financing conditions in purchasing AEVs
	MK-3	Climate projects
	MK-4	PIMA plans
	DISSEMINATION AND AWARENESS ON ALTERNATIVE ENERGY SOURCES	
	DC-1	MOVEA web platform
	DC-2	Zero, Eco, C and B labels
	DC-3	Participation in the European Monitoring EAFO
	DC-4	Practical training in driving alternative energy vehicles
	DC-5	Vocational transport sector training in alternative energy vehicles
INFRASTRUCTURE	IFR-1	MOVEA-Infrastructure Plan
	IFR-2	Boost participation in the INTERREG Cooperation Programme
	IFR-3	Boost participation in projects of common interest in the trans-European networks (TEN-T)
	IFR-4	Financial support for the deployment of supply infrastructure to municipalities
	IFR-5	Installation of recharging stations for electric vehicles at train stations and airports
	IFR-6	Spanish-Portuguese-French initiative to encourage electric vehicle
	IFR-7	Installation obligations for recharging infrastructure, ITC-BT-52
INDUSTRIAL PRODUCTION	FIDI-1	Programme of Innovative Business Groups (AEIs).
	FIDI-2	Lines of RDI linked to alternative energies
	FIDI-3	Encouraging participation in JTIs and PPPs at European level.
	FIDI-4	National Plan for Smart Cities.
	FIDI-5	Boosting Technology Platforms for the development of AEVs
	FIDI-6	Boosting centres and research infrastructure for the development of AEVs
REGULATORY FRAMEWORK	**REGULATIONS**	
	NR-1	Role of recharging manager. Analysis of adaptation of this role to market requirements.
	NR-2	'Supervalle' (super-off-peak) electricity tariff.
	NR-3	Technical instruction for the infrastructure for recharging electric vehicles (ITC BT-52).
	NR-4	Analysis of tolls for recharging points.
	NR-5	Authorisation to install recharging stations in residential buildings.
	NR-6	Exemption in compliance with the terms for licences to hire out vehicles with drivers.
	NR-7	Vehicle registration with recognition in the approval of a higher maximum authorised mass.
	NR-8	Traffic lanes for high-occupancy vehicles – HOV
	NR-9	Minimum mandatory targets for biofuels.
	NR-10	Inclusion of environmental criteria in tendering for public passenger transport services.
	NR-11	Inclusion of AEVs in the catalogue of the Framework Agreement for renewal of state-run fleets
	NR-12	Participation in Technical Committees for Standardisation (ISO, CEN/CENELEC and AENOR).
	TAX INCENTIVES	
	IF-1	Relief on vehicle tax (IVTM)
	IF-2	Relief on registration tax (IESDMT)
	IF-3	Income tax reduction applicable to employment income in kind

2.3.3. Spain's national policies for hydrogen

Thus, European Union Directive 2014/94 obliged each member country to develop a National Framework for Alternative Energy in Transportation before the end of 2016. Hydrogen, unlike other fuels (such as LPG or biofuels), has its own chapter in the Directive and although the development of infrastructures for refuelling (hydrogen) is optional, Spain has decided to consider it in the National Action Framework given the potential for the country. (Included in the ANEX).

This strategy is to be the skeleton for the development of the market for alternative energies in the transport sector and the implementation of the corresponding supply infrastructure involves the implementation of a performance of essentially structural nature, aiming at continuity in the long term. It includes a detailed analysis about the current situation of Hydrogen as an alternative energy source in each mode of transport and the expected scenario in terms of market developments. Also, the most important areas in which there should be action to support its implementation in transport are identified with, for each field, actions that can help achieve the objectives set out.

The document includes the Hydrogen production and consumption is designed and distributed in Spain, along with information about the development of Hydrogen refueling infrastructure, the fleet if vehicles and gives a general description of the current situation and expected market trends and objectives regarding road transport.

In Spain, one of the main challenges to overcome in order to accomplish the everyday use of hydrogen is to generate a market with enough critical mass; objective that has been strongly driven in the already mentioned Directive. Transport is, today, the leading application of the hydrogen and fuel cells and in Spain has a great potential to supply renewable hydrogen to the transport sector, so the expectations concerning the development of this technology is theoretically very high.

Currently there are six operation hydrogen refueling stations, located in Andalusia (Sanlúcar the largest and Seville), Aragón (Zaragoza and Huesca) and Castilla - La Mancha (Albacete and Puertollano), all of them need to be repowered to 700 bar, now that they currently supply to 350 bar. These six, will be soon added to other three in Aragón and one in Catalonia thanks to the H2PiyR - POCTEFA Interreg project which seeks to develop a cross-border corridor of hydrogen stations between Spain, Andorra and France. However, the six existing refueling infrastructure together with the 4 new ones that will be installed, need to be pass from experimental refueling infrastructures to become power infrastructures of public refueling use.

The only existing hydrogen vehicles in Spain are linked to R&D and demonstration projects since there are no commercial vehicles registered in Spain. This is a situation that, specific projects such as the H2PiyR, will try change by introducing 16 electric vehicles with hydrogen fuel cells (eight vans, six cars and two buses) in Spanish roads.

The strategy foresees (according to expected developments for the market) that Spain will have 20 hydrogen stations operating in 2020 and approximately 500 electric vehicles powered by hydrogen.

2.3.4. Autonomous Region of Canary Islands' policies for hydrogen

Found in the **National Framework for Alternative Energy:**

No.	MEASURE	COMPETENCE	NORMATIVE	ENERGY
	SPECIFIC REGIONAL STRATEGY			
1	SPECIFIC STRATEGY TO ENCOURAGE ENERGY ALTERNATIVES IN THE CANARY ISLANDS The Canary Islands are shaping their strategy which will focus on electric propulsion and hydrogen in the medium term.	Directorate General of Industry and Energy	Adoption foreseen for the first half of 2017.	Electricity Hydrogen
	MARKET: DISSEMINATION			
2	PLATFORM FOR ELECTRIC VEHICLE DEVELOPMENT IN THE CANARY ISLANDS It aims to be a meeting point for all entities related to electric vehicles, with the aim of: (1) minimising most existing barriers and enhancing the benefits of electric vehicles, (2) generating demand in society by promoting and explaining electric mobility, (3) adapt the energy, automotive, information and communications technology sectors, and new emerging sectors around electric vehicles, (4) establish the necessary synergies between efficient modes of transport and EVs and (5) ensure sustainable development of electric vehicles in the Canaries.	Department of Employment, Industry and Commerce	Collaboration agreement	Electricity

Hydrogen part of the **Intelligent Specialization Strategy of the Canary Islands (2014 -2020).** Focusing in developing an intelligent touristic sector, the strategy includes hydrogen as one of the alternative fuels that can be introduced in the Canary Islands facing the opportunities and challenges in transport and sustainable mobility, being ideal for testing new technologies and new business models related to sustainable mobility: progressive implementation of the vehicle electric and supplied with other "sustainable" fuels in tourist settings, management of fleets of vehicles for hire, innovative models of car-pooling and car-sharing, development of "sustainable" tourist routes, etc.

The Energetic Strategy of the Canary Islands 2015 -2025 also includes hydrogen under its Axis 2: Transport. Reduce the oil dependence in transport, especially in the road transport sector. Action Line 2: Promotion of the use of alternative fuels (non-electric) in ground transportation. Initiative E2_2.2 Development of infrastructures to encourage the use of alternative vehicles.

2.3.5. Other hydrogen projects

1. European Proyecto HYACINTH http://hyacinthproject.eu/

2. HIT 2 Corridors http://hit-2-corridors.eu/
3. FREVUE project http://www.frevue.eu/
1. Green eMotion project http://www.eafo.eu/sites/default/files/Final%20report%20Green%20eMotion%20project.pdf
2. I-CVUE Project http://icvue.eu/
3. Eliptic http://www.eliptic-project.eu/
4. HYLAB - Laboratorio de Tecnologías del Hidrógeno: http://www.itccanarias.org/web/itc/proyectos-eerr/hylab.jsp?lang=es
5. PSE H2RENOV - PSE Hidrógeno Renovable
6. http://www.itccanarias.org/web/itc/proyectos-eerr/pse_h2renov.jsp?lang=es

7. Enagás y Redexis impulsan un proyecto de hidrógeno renovable. 08.03.2018. 'H2Gas',
8. https://www.laopinion.es/economia/2018/03/09/enagas-redexis-impulsan-proyecto-hidrogeno/857916.html
9. http://futurenergyweb.es/en/enagas-and-redexis-gas-create-h2gas-to-boost-renewable-hydrogen/

10. ELYGRID (2011-2014) and ELYNTEGRATION (2015-2018): involving implementation of a traditional alkaline electrolysis system for electricity management systems in networks with high penetration of renewable energies. http://www.elygrid.com/ , http://elyntegration.eu/

11. ELY4OFF (2016-2019): Improved electrolysis system for managing electricity in networks with high penetration of renewable energies.

12. RENOVAGAS ‘Renewable Natural Gas Generation’ project based on the Power to Gas technology to develop a production plant for synthetic natural gas from biogas by methanation of hydrogen obtained from renewable sources. It is led by ENAGAS and has the participation of the Centro Nacional del Hidrógeno (CNH 2), Abengoa Hidrógeno, Gas Natural Fenosa and FCC

13. AQUALIA, the Tecnalia Research & Innovation Foundation and the Institute of Catalysis and Petrochemistry of CSIC (ICP-CSIS).

14. SOTAVENTO: Development of a system of hydrogen production from wind energy in Galicia.

15. ITHER: Project for the implementation of an infrastructure for hydrogen production from renewable energy from a wind farm and a photovoltaic solar plant, for storage and use in fuel cells. In 2010 it received an award from the International Energy Agency.

16. HYUNDER (2012-2014): Project to study the feasibility and business models associated with the use of mass hydrogen storage underground to balance the network when large amounts of renewable generation are added to electricity mix.

17. ZEROHYTECHPARK: Project aims to create sustainable technology parks with practically no emissions by using hydrogen generation from renewable sources for use in sustainable mobility, and by implementing energy efficiency measures in the different infrastructures of such parks.

18. RES2H2 – ITC http://ieahydrogen.org/Activities/Selected-Case-Studies/Renewable-Hydrogen-Project-(Spain).aspx
19. RES2H2 Este proyecto preveía dos experiencias demostrativas, una en España y otra en Grecia, sobre las posibilidades que brindan el binomio energías renovables/tecnologías del hidrógeno. El prototipo español consistió en un sistema energético integrado para la producción controlada de energía eléctrica y agua (en Pozo Izquierdo), compuesto de un aerogenerador, un electrolizador, un sistema de almacenamiento de hidrógeno, una pila de combustible y una planta desaladora. El sistema griego abarcó la producción de hidrógeno mediante un electrolizador conectado a red y su posteriormente distribución a la industria química. Con el desarrollo de este proyecto se priorizó el avance en el conocimiento de las tecnologías del hidrógeno, y con la inauguración de la planta piloto del proyecto RES2H2 y la celebración de dos reuniones de trabajo de dos grupos de la Agencia Internacional de la Energía en Pozo Izquierdo, se reforzó el posicionamiento de Canarias en el mapa mundial de las tecnologías del hidrógeno.

3. Annexes

National Action Framework For Alternative Energy In Transport Market Development And Deployment Of Alternative Fuels Infrastructure. In compliance with Directive 2014/94/EU of the European Parliament and The Council, of 22 October 2014.

Intelligent Specialization Strategy of the Canary Islands (2014 -2020)

The Energetic Strategy of the Canary Islands 2015 -2025