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Spanish end vision document after 2nd Spanish workshop.

1.- LONG TERM VISION OF A SUSTAINABLE ENERGY SYSTEM (2050)

Nowadays, Spain imports almost the 82% of its energy. The scheme of participation on Primary Energy Consumption is the following: Renewable Energy: 5.95% (Biomass 2.8%, Hydro 1.2 %, Wind 1.2%, Solar 0.045%, Organic Domestic Waste ODW 0,3%, Biogas 0.2 %, Biofuel 0.2%, Geothermal 0,01%), Petroleum energy: 49.3%, Natural Gas 20.0%, Coal 14.6%, Nuclear 10.3% , Electric balance -0.1% *(IDAE, 2005)*. 26% of this energy is dedicated to household and public service sector, 41% to transport and the remaining 33% to industry. Energetic demand is increasing very fast due to the electricity and transport sector demand. This has involved an increase in the Primary Energy Consumption of 5% in the 90´s.

This situation together with the Kyoto protocol requirement has made the Spanish government act with new initiatives: The Action Plan 2005-2007 to promote the "Energy Saving and Efficiency Strategy 2004-2012" and the new "Renewable Energy Plan 2005-2010". A great potential of wind and solar power energy for combined heat and power use will be developed in order to produce electricity as an energy carrier. CCS should be solved to continue using coal gasification which today is the most competitive process for H_2 production at large scale.

Nevertheless Spanish future energetic system will continue being 40% fossil fuels based, mainly central generation with CO2 free Coal Gasification (Puertollano in Castilla la Mancha counts with one of the two Integrated Gasification Gas Combined Cycles (IGCC) plants existing in Europe), although 40% of renewable energies emissions free plants with on-site distribution is expected. 20% of Advanced Nuclear Energy will be necessary to cover the energy demand but its increase will depend on policy framework.

2.- THE ROLE OF HYDROGEN IN THIS SUSTAINABLE ENERGY SYSTEM .

HYDROGEN DEMAND.

The added value that H_2 can introduce to energy system is its combination with renewable energies avoiding their intermittence and reducing Spanish dependence from external energy, specially fossil fuels. Besides the benefit that will appear from the use of H_2 as energy vector is the flexibility it introduces for choosing the primary energies from which to obtain fuels for transport applications. It will make possible to choose the cheapest option and the most convenient (renewable, nuclear or fossils fuels) depending on the application. Furthermore, H_2 will help to provide a healthier environment in city centres where air pollution is so high.

In the near term, the high price of H_2 technology (fuel cells) and its complexity for individuals remain as the main limitation for a big development of H_2 economy in Spain. Therefore, H_2 for transport will be used only in captive fleets. A mixed technology of fuels is expected with a relevant role for biofuels because of the easiness to adapt current infrastructure to their infrastructure. Although the use of biofuels for transport will increase during the near and intermediate period, they won´t provide the definitive solution for air pollution as they continue emitting NO_x and particles. Therefore, in the near and intermediate period the tendency will be the use of hybrid-electric vehicles (HEVs) which use internal combustion engines and electric batteries to power electric motors. Fuel used for hybrid vehicles will come from a variety of sources: gasoline, diesel, biofuel, H_2, etc. These vehicles will help to increase the energetic efficiency and reduce petroleum products consumptions.

Portable applications like mobile phones, UPS, APS, etc, will be the first market to introduce H_2 to general public.

In relation to stationary uses, household, public services and industry energy demand will be covered mainly by electricity. Electricity infrastructure is already developed whereas H_2 pipeline nets would have to be installed throughout the country which would be too expensive. That is why electricity is selected as the main energy carrier and not H_2. However small H_2 pipeline nets are expected to appear near industries, on-site H_2 facilities production plants and niches like new housing development or isolated areas where the installation of H_2 pipelines can be as expensive as power lines.

Hydrogen production in 2050.

H_2 production will be determined by regional features. Renewable energies (wind, solar thermal and biomass) will produce 40% of H_2 in 2050. The rest 60% will be produced in a diversified way, including fossil fuels with CCS, nuclear and electricity mix. Feedstock price will dominate the production costs, specially petroleum and natural gas, and coal gasification with CCS will turn out to be the most economical option for the co-production of electricity and H_2. A multiplicity of on-site (decentral) H_2 production facilities is expected and few central ones. Finally, no H_2 exportation to other countries is foreseen.

Both trucks and pipelines will be considered to transport H_2, liquefied (LH_2) and compressed gas (CGH_2) by truck and only compressed gas (CGH_2) by pipeline. Nowadays, CGH_2 is transported by truck for short distances and small quantities (no more than 400kg/truck for 400km.) and LH_2 by truck is chosen when bigger distances and quantities are demanded. Although at present there is no liquefaction plant in Spain, once demand reaches relatively high value they will be built. It is expected that Spain counts with one of this liquefaction plant by 2020, so in 2050 a few central ones are expected. There already exists a 25km. CGH_2 pipelines net in Spain. It is used for industrial application and is located near production centres. H_2 transport by truck (CGH_2 and LH_2) will increase progressively with the demand and only when consumption turns out to be high, will largest pipelines for CGH_2 transport appear. It will become the most attractive option for significant quantities of H_2 delivery, whereas transport by truck will be used for limited quantities. Filling stations will be set every 100km.

3.- THE ROLE OF HYDROGEN IN THE INTERMEDIATE PERIOD (2020, 2030):

In the transition period the growth of H_2 demand will enlarge the options for centralised and decentralised H_2 production. H_2 will be obtained from: decentralised fossil fuels like NG and liquid hydrocarbons, central coal gasification and first wind and solar thermal power facilities.

The carbon capture and storage technology will be envisaged during this phase at industrial scale.

Referring to transport, H_2 and natural gas mixes are considered the most probable transition technology to be used in internal combustion engines as fuel and to be transported by pipelines as a way to transport H_2. It is important to note that in Spain exists a good experience in the use of compressed and liquefied natural gas (CNG and LNG) for transport referring to vehicle engineering, development and refuelling infrastructure.

4.- THE ROLE OF HYDROGEN IN FIRST MARKETS (<2020)

The early markets identified are: portable applications where metal hydrides will be developed as storage system, captive fleets in Madrid and Barcelona (e.g. urban buses or low power airport vehicles) where there is a previous experience with H_2 vehicles due to their participation in

European programmes, captive fleets in small cities where H_2 initiative is easily seen and supported by political commitment and stationary use prototype installations.

The first user centres identified are: Madrid, Barcelona, Zaragoza, Pamplona and Valencia. The construction of new refuelling stations will be needed is all these cities.

First H_2 vehicles prototypes will lead to a new vehicle components industry like fuel cells, compressors, humidifiers, batteries, etc…It will be necessary to coordinate vehicle assembly plants through an "H_2 ring" that connects those cities where vehicles and their components are manufactured.

5.- POLICY SUPPORT

The scenarios contemplated in this document are strongly dependent on policy framework, specially regarding to nuclear energy and H_2 use. At national level there is no specific action or development strategy to introduce H_2, it is just considered as an emergent technology as many others in the National Energy Plan. First of all H_2 should be introduced in National Energy Plan as an independent technology and a National Master Plan should be established to develop H_2 structure. As it is happening with some renewable energies there should exist tax relief and subsidies for promoting H_2 systems at National scale as well as a harmonization of codes and standards. Curricular integration of H_2 at different levels should be carried out in next years.

Ecological criteria should be taken into account in tax rates: taxes should be imposed on mechanical traction vehicles based on CO_2 and other pollutants emissions and in low energetic efficiency vehicles. In addition, diffusion and promotion of lighthouse projects and technological advances should be emphasized, public subsidies for generated employment, CO_2 emissions avoided and to buy H_2 vehicles should be created.

Not only National government should be aware of the necessity to support H_2, but also regional and local governments should contribute to the development of initiatives to make H_2 visible and familiarize people with the new technology in small areas where public awareness can be more easily reached. Such big differences exist among policy frameworks at regional levels that it makes impossible to establish a "H_2 ring" or highway between regions. Therefore, H_2 should be introduced in Regional Energy Plan and regional policies should be harmonised. For example, ecological criteria for taxes, grants for "green" H_2 production, subsidies for free emissions vehicles as precursors of H_2 ones and exemption for the parking payment for H_2 vehicles are some of the proposed measures. Moreover, the use of H_2 vehicles in public and official fleets and economic support for large scale demonstration projects should be promoted.

Spain should get involved in big R&D projects and follow European legislation concerning H_2 and fuel cells as well as foster its representation in European forums by Spanish experts involved directly in hydrogen technology and development.

At European level, it could be useful to launch a Joint Technology Initiative (JTI) in hydrogen and fuel cell, develop procedures, specifications, standards, regulations for equipments, safety and quality and fiscal harmonization on taxes based on pollutant and energetic efficiency criteria.