Research Group on Energy & Sustainable Development

Road Map for Portugal

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Overview

- Hydrogen Roadmaps
- Origins of the Portuguese Roadmap
- Methodology & Assumptions
- Modelling
- Results
- Impacts
- Conclusions

The Hydrogen Economy

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- HYDROGEN represents a promising way to a more sustainable energy system. However, R&D is still needed to cut costs, improve performance and evaluate advantages and obstacles to the introduction of hydrogen into transport and power generation markets.
- Many regions of the world have developed, or are making efforts to prepare a hydrogen roadmap.

A Hydrogen Roadmap is:

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- A JOINT ENDEAVOR of industry, government, academia and the public providing a structured process for a coordinated, long-term effort in preparing, introducing and implementing hydrogen into energy and transport systems.
- AN IDENTIFICATION INSTRUMENT for the key technologies, products and markets, together with foreseeable obstacles to their development, introduction and use, and the possible measures to be overcome.
- AN ASSESSMENT of expected impacts on the market, society and environment.

A Hydrogen Roadmap is:

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- A NAVIGATION TOOL for strategic planning and implementation of research development, structural changes and infrastructural investment.
- AN OPPORTUNITY FOR COMMUNICATION between all involved stakeholders of different backgrounds, viewpoints and interests.
  - Provides a national platform to encourage the development of a hydrogen economy
- A TECHNICAL, ECONOMIC AND STRATEGIC ANALYSIS leading to a master plan with a derived list of actions based on a combination of visions pathway scenarios and systems modeling.

Origins of PT Roadmap

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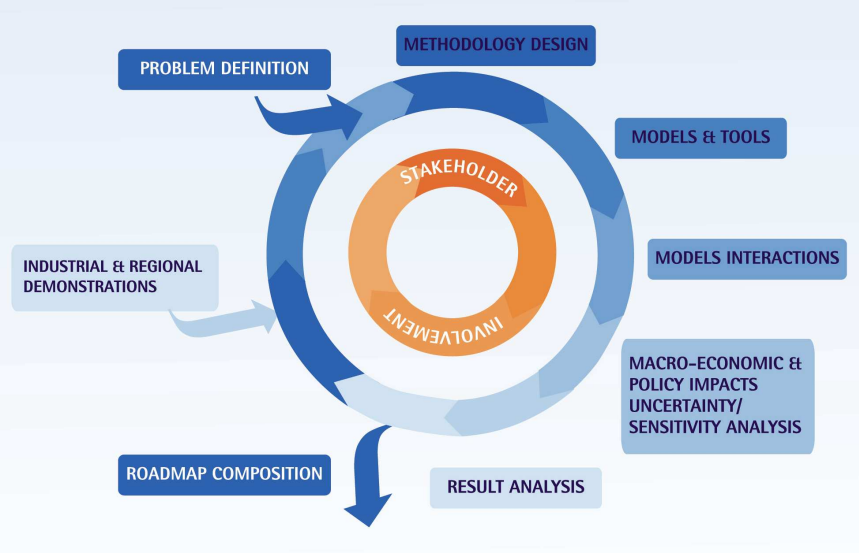
- Origins of Portuguese hydrogen energy roadmap go back to 2003
  - Group of interested parties led by SRE began negotiations with the Agency for Innovation for a proposal on new energy technologies that facilitate the growth of the hydrogen economy.
  - Government sponsor – not driver
- Actual Start – October 2006
- 2003-2006 - Portuguese institutions became involved in a series of pan-European hydrogen related research projects.

HyWays Recommendations



Methodology

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- Vision building through Stakeholder participation - HI-PO
- SCENARIOS DEVELOPMENT
  - Scenarios workshop
  - Scenarios development
  - Consultation with experts
  - Final set of scenarios
- MULTI-CRITERIA ANALYSIS
  - Definition of stakeholders' panel
  - Multi-criteria mapping interviews
  - Analysis of the interviews' results
- PATHWAYS & ROADMAP
  - Pathways analysis and contribution for the definition of a hydrogen roadmap

hi-po development of hydrogen in portugal

Assumptions

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- Assumptions are very important
  - Can change the results dramatically
- Main Assumptions
  - Fossil Fuel Price evolve over time (but high level of uncertainty)
  - Share of renewable energy in the Hydrogen Production
  - Costs and cost evolution of the Hydrogen technologies (high level of uncertainty, lack of validated sources of information)
  - Ban on nuclear
  - No “conventional” Coal Power Plants without carbon sequestration will be implemented from 2015 onwards

Scenarios

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- Baseline scenario of business as usual
- High penetration rate
- Moderate penetration rate

These scenarios have a mandatory target for hydrogen technologies for the transport, residential and commercial sectors at two different penetration rates

Penetration Rates

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Transport

Scenario / Point in Time	2020	2030	2040	2050
High penetration	3.3%	23.7%	54.4%	74.5%
Moderate penetration	0.7%	7.6%	22.6%	40.0%

Stationary

Scenario	2020		2030		2040		2050	
	Res	Com	Res	Com	Res	Com	Res	Com
High penetration	1%	0.3%	4%	1.3%	8%	2.7%	10%	3.3%
Moderate penetration	0.1 %	>0%	0.5 %	0.2%	2%	0.7%	5%	1.7%

Bounds

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Minimum share of renewable energy in hydrogen production

2020	2030	2040	2050
20%	26.7%	33.3%	40%

Technology-specific bounds for hydrogen production

Technology/fuel	2020	2030	2040	2050
Biomass	>5%	5-15%	5-15%	5-10%
Wind	>7.5%	>10%	>20%	>20%
Wave	>2.5%	>5%	>5%	>7.5%
Centralised production with CCS (coal and natural gas)	<20%	<20%	<15%	<10%
Solar thermochemical cycles		<15%	<20%	<30%

Models used

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- **TIMES –** dynamic cost optimisation model to determine the lowest cost technology solutions to satisfy both the demand and any set of restrictions. It targets *technological, environmental* and *economic impacts*.
- **Copert –** model for calculating pollutant emissions such as (CO2, CO, NOx. SOx) from the transport sector. It targets *environmental* impacts.
- **ISIS –** input-output model for calculating the *social* impacts of the introduction of hydrogen.
- **Infrastructure analysis –** semi-quantitative process of determining geographical distribution of hydrogen technologies over time.
- **KCAM –** fully qualitative systematic process for collecting the views of the stakeholders. Identification of key changes needed for a successful hydrogen introduction in the Portuguese energy system.

Modelling

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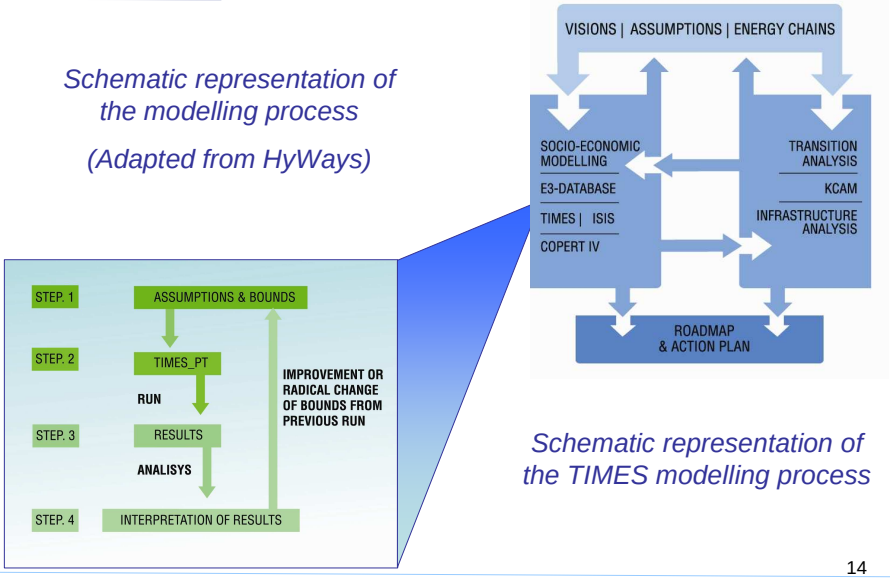
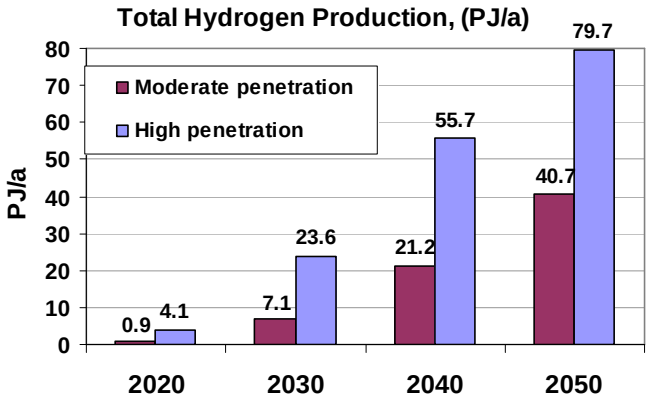
Schematic representation of the modelling process

(Adapted from HyWays)



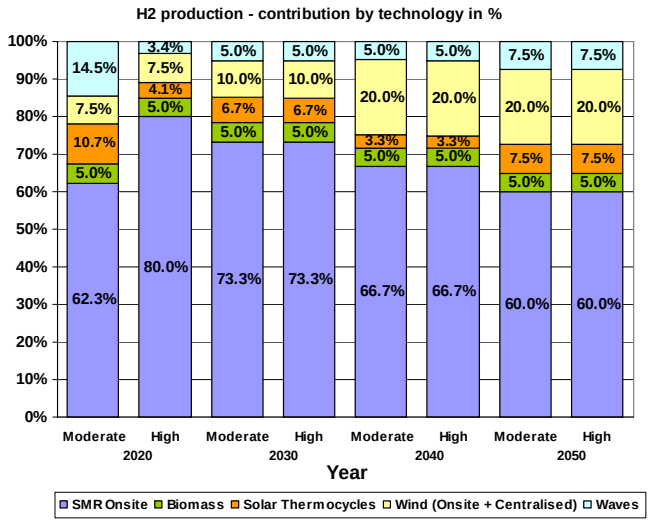
Schematic representation of the TIMES modelling process

Total Hydrogen Production



- Mainly for transport sector
- Transport by truck, 90% as compressed hydrogen

Hydrogen Production Mix



CO2 & GHG Emissions:

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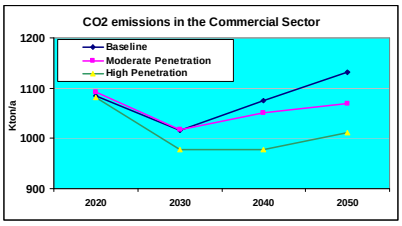
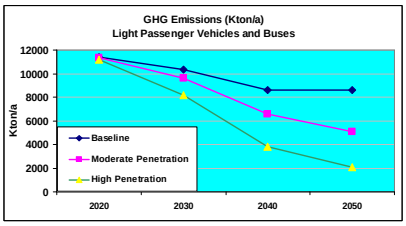
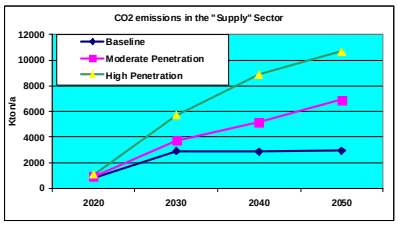
Commercial



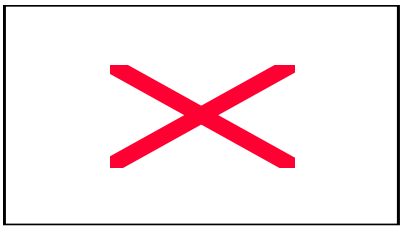
Transport



Supply Sector



Total GHG emissions



CO2 emissions: & driving cycle

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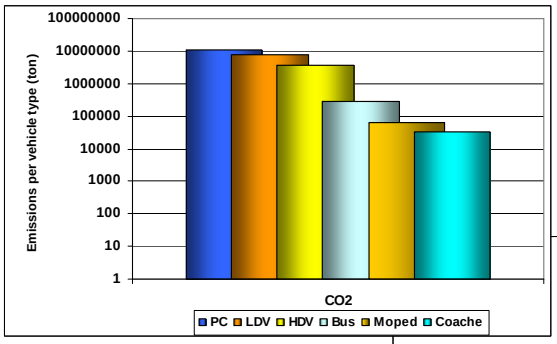
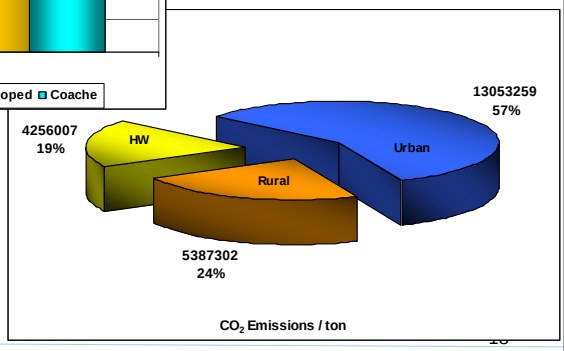


According to vehicle type

According to driving cycle



Astra Modelling Results

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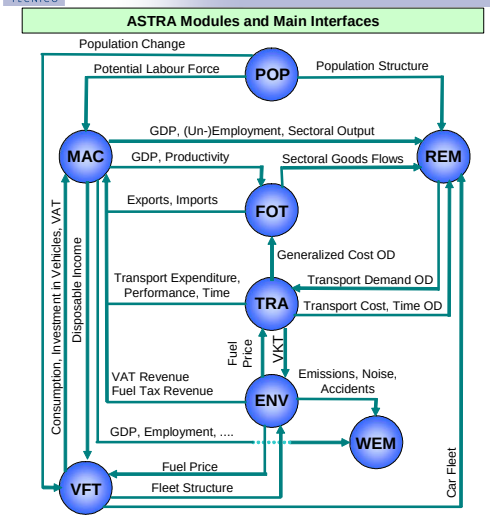

- Results are a first iteration

Impact on economic indicators

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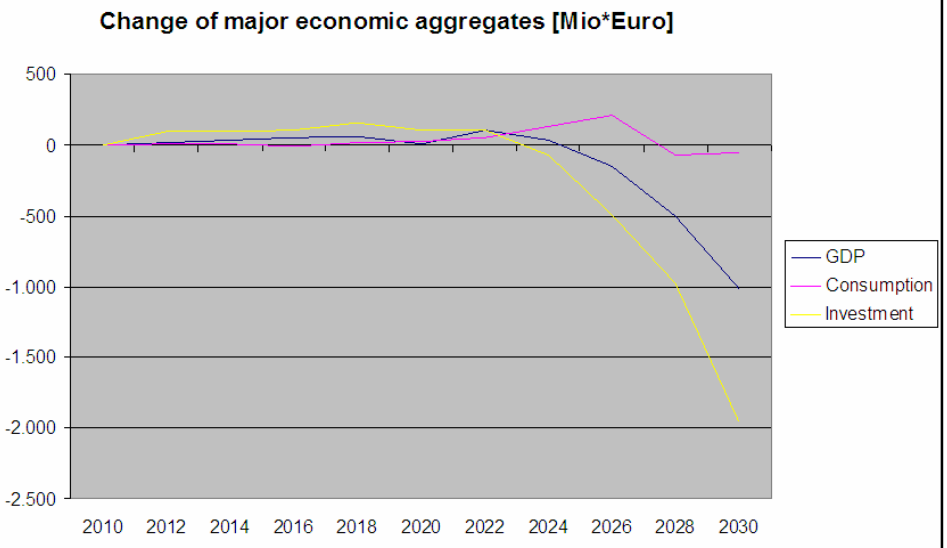
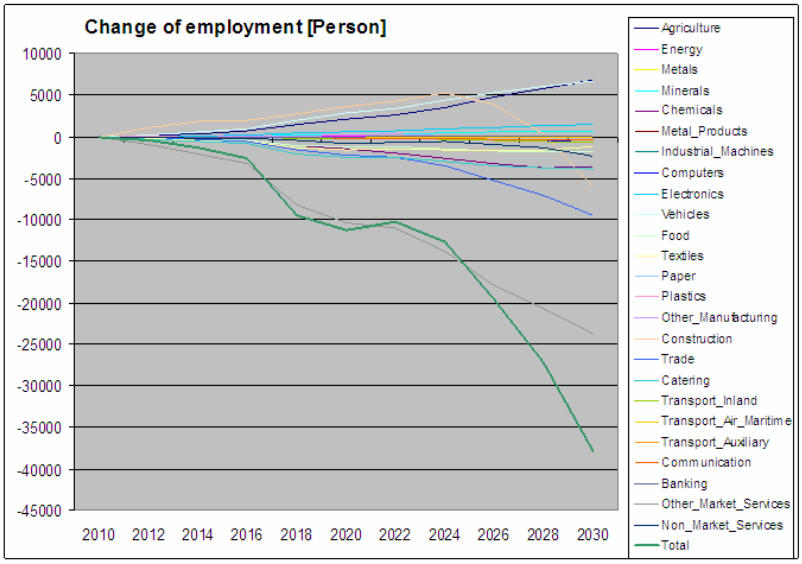


Impact on Employment



Overall Impact

- Overall macro-economic impacts for Portugal are negative *(for the assumptions & bounds chosen!)*
  - H2FCV not cost competitive
  - Higher investment and running cost for hydrogen vehicle
- High level of hydrogen produced from renewables
  - Renewable strategy may lead to other benefits like reduction of pollutants and improvement of security of supply
- Indicators (hydrogen production or fuel cell patents and demonstration projects) Portugal is not well-placed compared to leading countries in these areas

Next steps

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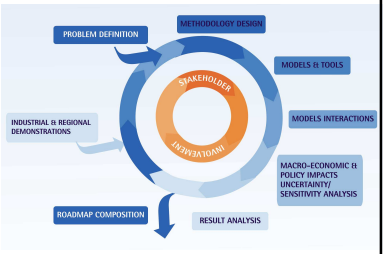
- Results are a first iteration
- Results differ from HyWays study for other European countries
- Assumptions have to be revisited
  - Reliability has to be proved in an additional study
- Closer examination of assumptions & bounds in HyWays & this project



Prospects for Portugal

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Portugal has a high potential for the production of hydrogen on the basis of renewables

- Portuguese industry
  - Experience in the field of conventional car manufacturing
  - Possibility of successful export orientation in special technology fields
  - Some experience with the production of hydrogen
- An adequate industry policy may offer the possibility to change the competitiveness situation of Portugal

Concluding remarks

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- It is not an event
- Marks the beginning of a process
- Portugal has gained some experience
- Have a team and consortium with considerable capacity

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Thank You for your attention

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