HYDRA: Platform for clean energy

"Towards the energy transition based on plasmonic systems"

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Global Challenges

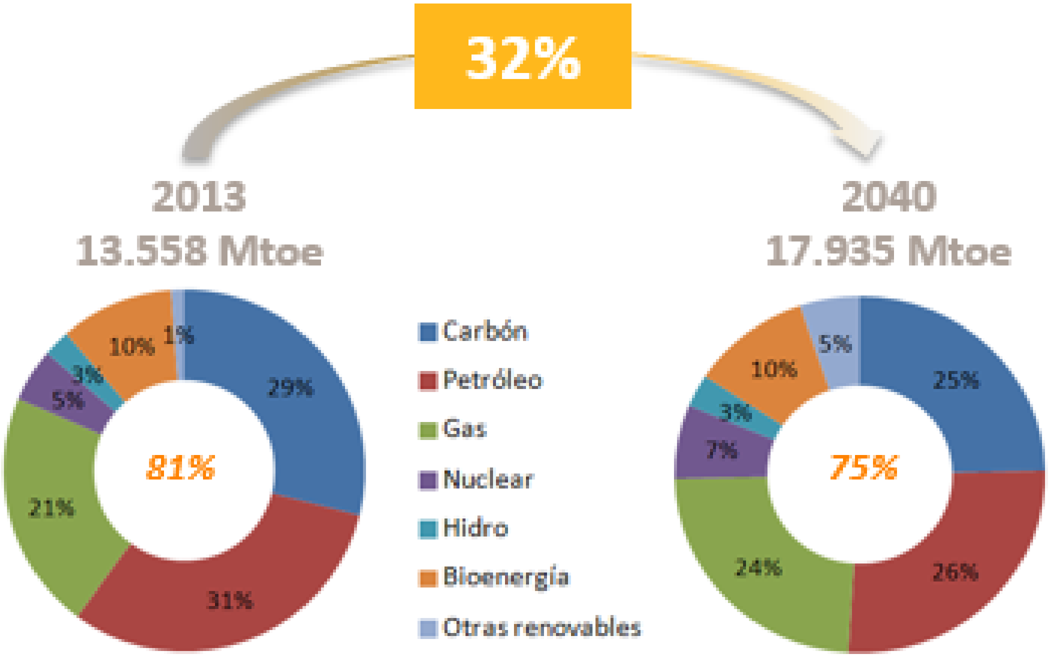
Nowadays…

- Greenhouse gas emissions are raising the temperature of the earth
- Polluting emissions are causing harmful effects on health
- Renewable energy is the engine of change for energy transition
- Hundreds of millions of people lack basic energy services. Distributed systems are needed.
- The improvement of energy efficiency is a necessity (cheaper energy, with greater availability and less polluting)

Future Challenges

- Population growth (9 B in 2050)
- Growth in energy demand, due to the growth of urbanization and the level of income (+ 30% up to 2040)
- Commitment to a temperature increase of less than 2ºC
- Electricity advances more and more in the growth of energy consumption
- An additional USD 23 trillion is required up to 2040 to improve energy efficiency. Especially in buildings and electric power generation
- Efficiency will be the engine of change
- Increasing cyber-attacks to centralized systems

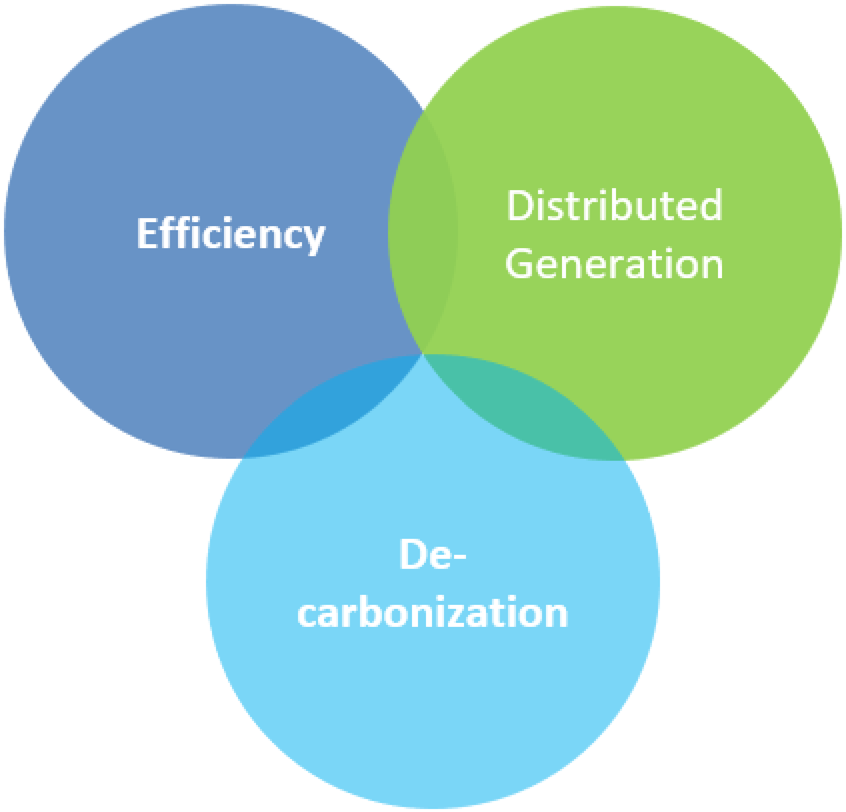
The energy transition is already underway



Fuente: IEA WEO, 2015. *New Policies Scenario*

To meet the growing global demand for energy with safe supplies and in an environmentally friendly manner, it is necessary to **encourage technological innovation** with the aim of moving towards **de-carbonization**, improving **efficiency** and developing **distributed generation** systems.

What is proposed?



The new **Hydra Energy Platform** will enhance the **energy transition**, given that the technology to be developed is characterized by being **clean**, without generating polluting gases, **efficient** with lower costs than conventional ones (order of magnitude) and favoring **distributed generation.**

This Platform could be the basis of a **revolution in the global energy model.**

Challenges vs opportunity

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It has been observed that ...

- Using **plasmonic nanoparticles** it is possible to locate energy efficiently
- In this way it is possible **to overcome the activation barrier of various reactions** and promote efficient catalytic pathways
- Application to the **production of hydrogen** by solar energy is an attractive possibility that requires carrying out concept tests prior to the development of prototypes

Proposed challenges

- To identify and optimize the most relevant parameters to **generate and control the reactions required** by plasmonic systems
- To study and control the **effect of the plasmon that conduct** to:
  - High electronic density
  - Catalytic effect
- Conversion of **solar energy into H_2** through (photo-) thermo-chemical processes

Demonstration project phases

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Phase 1

Proof of Concept

(TRL 1 → 3)

- Demonstrate, at lab level, the viability of the direct conversion of electromagnetic radiation into chemical energy (H_2), with good efficiency.
- Validate the hypothesis through different plasmonic systems with good efficiency and without CO_2 emissions.

Stop / go?

If the result of the previous proof of concept is satisfactory, it would be necessary to continue with the following stages

Phase 2

Lab Prototype

(TRL 3 → 5)

- Lab prototype validated in this scale, and that allows the direct conversion of solar energy to H_2, reproducible, economic and non-polluting

Phase 3

Real Prototype

TRL (5 → 6)

- Optimize the lab prototype, apply and validate in real operating conditions

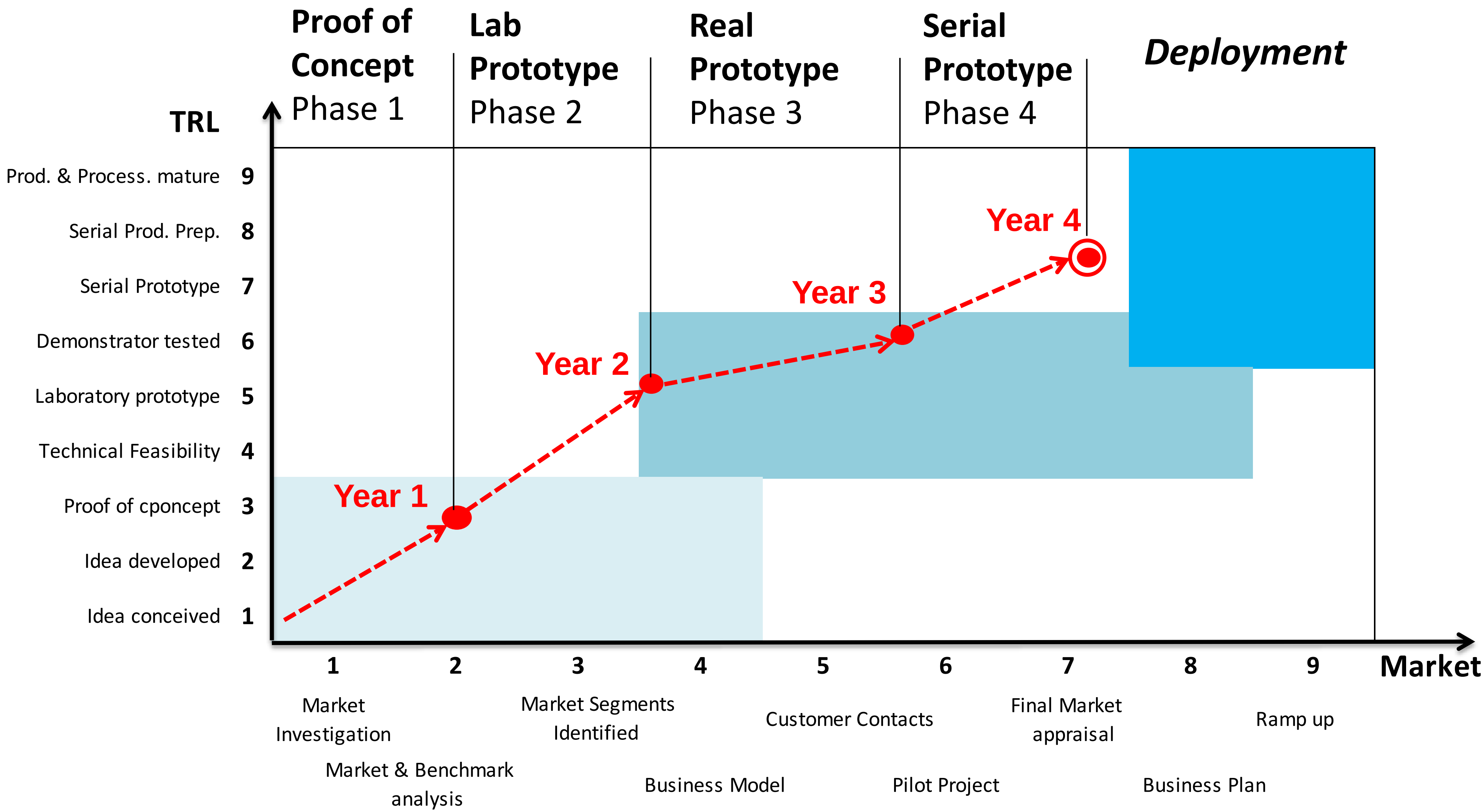
Phase 4

Serial prototype

TRL (6 → 7)

- Design and apply serial prototype, through a pilot market project

HYDRA Platform Roadmap



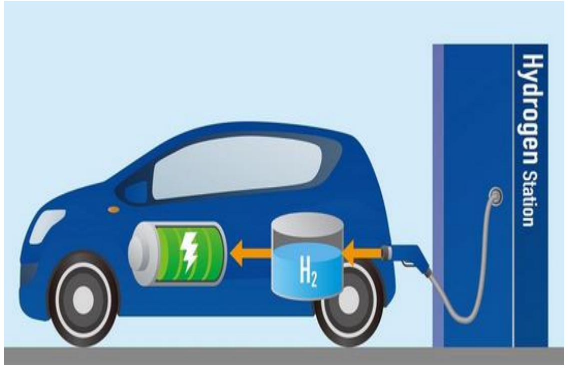
Application examples of the Technology

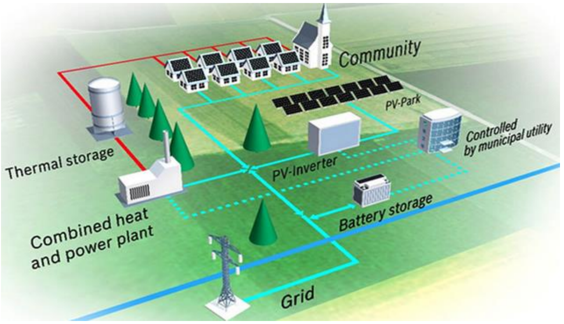
- H_2 has been selected as the first step in the development of the HYDRA Platform, given that H_2 can be **generated in a distributed way,** it would eliminate the need for expensive infrastructures, helping to boost an **economy based on H_2 as an energy vector.**

- Once the proof of concept (H_2) was successfully carried out, the foundations were laid to develop **compact systems** for the generation and accumulation of **modular energy**, with a **very attractive cost and without CO_2 production**.

- In **heat applications**, no additional conversion system would be necessary. Numerous industrial applications (e.g., refineries) or their use in EV with fuel cell (FC), would also **not require further conversion**.

- If **electricity generation is required**, the accumulated H2 could be converted into electricity, on demand, through proven, high-performance FC-based systems.





Necessary capabilities

Available capabilities

- Manufacturing and characterization of **nano-structured materials**, in particular plasmonic systems through different physical-chemical techniques.
- **Irradiation and in situ detection** of the reaction products.
- Separation of H_2 through conventional membranes.
- Simulation of the **plasmonic response** of complex systems.
- Simulation of the **structural stability** of plasmonic systems subjected to irradiation cycles.

Required Capabilities

- ***Ab initio* simulations** of the reactions involved in excited plasmonic surfaces and in different solutions.
- Manufacture by colloidal techniques of complex nano-systems based on several elements.
- Optimization of solid **catalysts** or in solution.
- ***In situ* characterization** of the plasmonic systems during irradiation.
- Manufacture of **standardized prototypes**.
- Separation of H_2 through **advanced membranes, of the latest generation.**

What are we looking for?

- Create strategic alliances with entities, institutions and companies
- Scientific and technological competences to complement the available ones
- Financing for the development of the project
- Involve stakeholders to support the project
- Boost the energy transition, demonstrating the feasibility of a new disruptive technology to generate clean energy, based on plasmonic systems
- Promote de-carbonization, efficiency and power generation in a distributed manner
- To promote an economy based on H_2 as an energy vector
- Expand the technology to be developed with H_2 to other applications
- Involve benchmark companies to scaleup the technology