Off-board storage & Stationary applications : a collection of "niches" of vital importance for the transition towards Hydrogen Economy

The history of photovoltaics

- First solar cells for space applications produced in the 1950's
- The first "oil shock" triggered ww solar programs at the end of the 70's
- In the 1980's thin film solar cells were expected to quickly replace crystalline Si solar cells and a price of 0.5 $/Wp was announced

BUT

- First photovoltaic products for housing were not reliable enough because of packaging
- Thin film solar cells did not meet expectations
- The price is still 1.5 $/Wp twenty years later

The history of photovoltaics

HOWEVER

- A collection of “niche applications” where the kWh price is secondary were found in consumer products, isolated sites, telecom power relays
- Niche applications helped the products to mature and the industry to enter a healthy market-driven learning process.

THEN

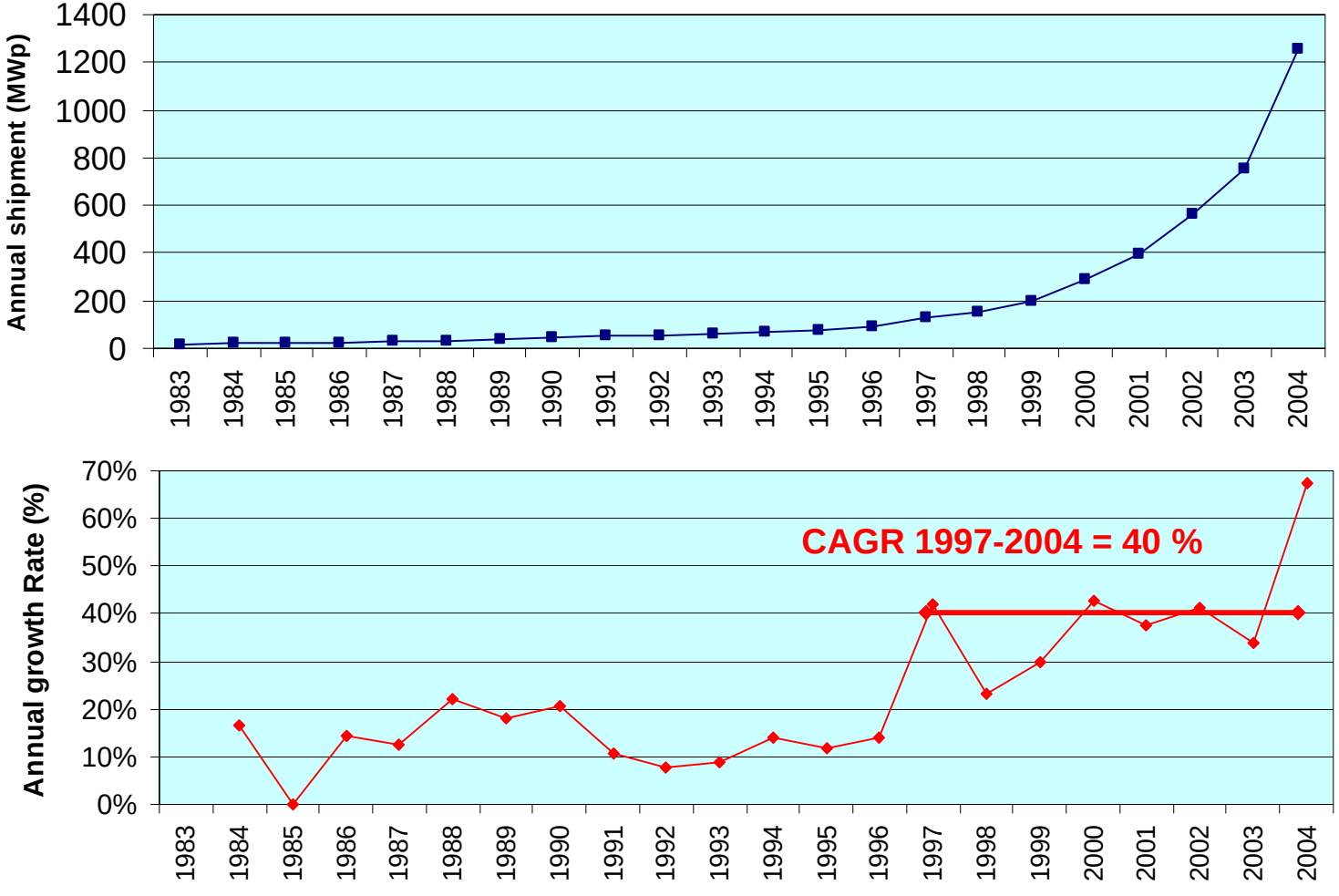
- A very intelligent “feed-in” law has been passed in Germany in the 1990’s to trigger domestic housing demand. This template is now repeated in Spain, Italy, Switzerland, etc…

AND

- The “Photovoltaics Economy” rocket took off …

The history of photovoltaics

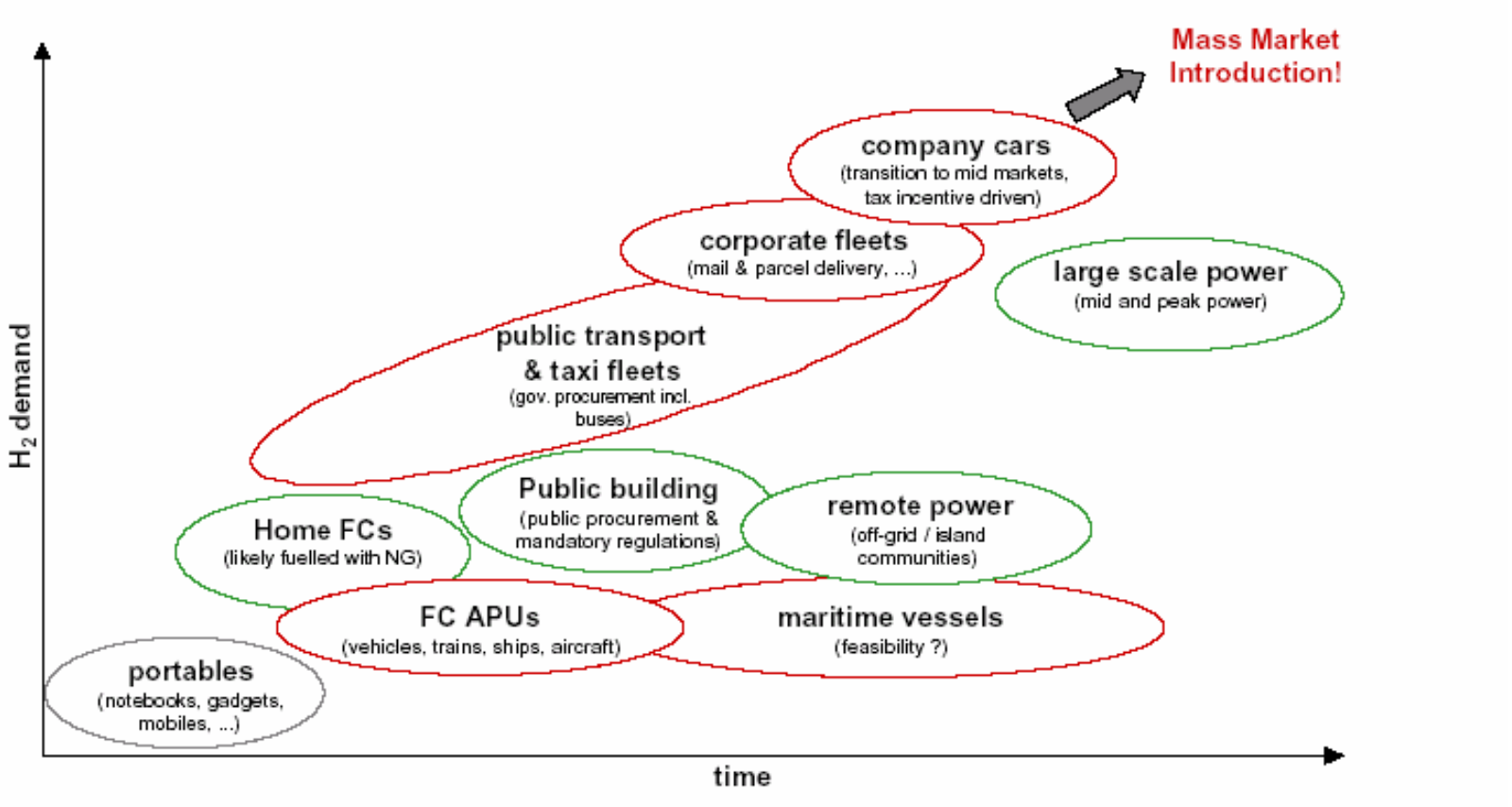
World annual shipment of photovoltaic modules



Conclusion : remember history

- Do not wait for hydrogen fuel cell vehicles to develop the “Hydrogen Economy” because they won’t be available during the next ~ 15 years
- Hybrid cars and ICE cars using pure H2 or H2/CNG (hythane) mixtures will make the transition towards H2 FC automotive market
- Emphasize “other than CO2 reduction” arguments in favour of H2 and FC niche applications : reduction of noise, reduction of local pollution such as unburnt HC particles and NOx emission (justification for hythane)
- Deployment of microeconomic H2 & FC logistics networks and niche applications in micro-vehicles (bikes) or macro-vehicles (buses, trucks, sub-marines …), and small stationary (portable FC, APU, UPS) will happen soon

Transition Scenario



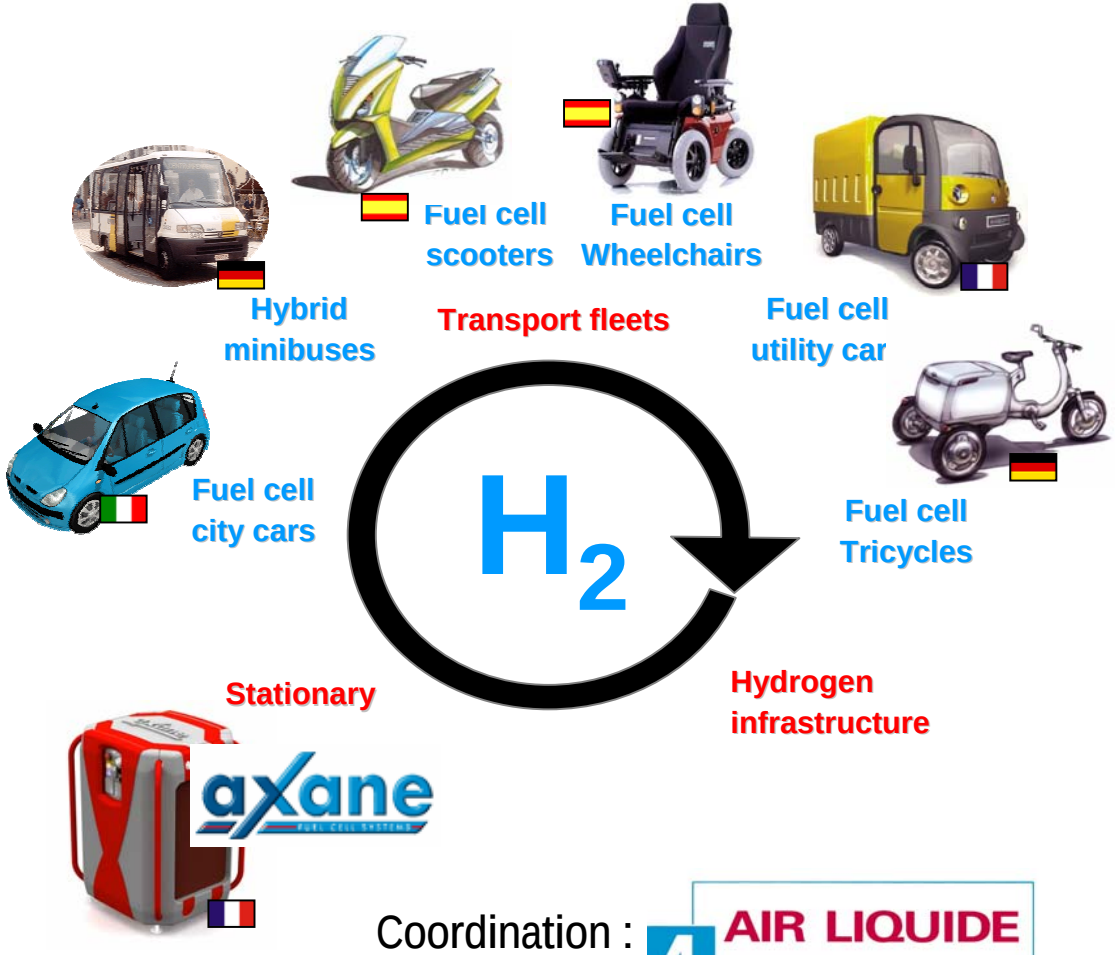
Expected introduction of hydrogen energy applications in various end-use sectors (red – transport, green – stationary, grey – portable)

HyNet

The HYCHAIN hydrogenchallenge European project

- Full H2 Economy implementation at small scale setting the framework for mass deployment

Oct 2005-Sept 2008
26 partners
4 European Regions
France, Italy, Germany, Spain



Coordination : AIR LIQUIDE

Solid Storage only when it makes sense ...

- Large stationary outdoor applications will always prefer H2 storage in compressed gas or liquid form.
- Solid hydrogen storage is primarily motivated by
  - High volume density (equivalent to > 1000 bars)
  - Safety because of low pressure at normal temperature
- Temperature-controlled metal hydride or physisorption tanks are inadapted to outdoor applications, where temperature cannot be controlled

Compromises ...

- Materials intrinsic cost
  - Better performance from AB to AB5 ⇒ higher cost of elements such as Vanadium
  - Why carbon nanotubes, when activated carbon is much cheaper and has the same performance ?
- Materials processing
  - Nanostructuring ⇒ less control of metal hydride stability upon cycling
  - Reduction of Mg-hydride temperature by fine ball milling ⇒ increased processing energy and cost
- Tank engineering
  - Fast adsorption-desorption ↔ improved heat exchanger ⇒ lower available H2 mass fraction
- Safety
  - Pyrophoric metal hydride materials

Potential "off-board" applications of solid storage systems …

- Small metal hydride cartridges, easily to manipulate for logistics, and preferably for indoor applications in cold countries …
- Fixed metal hydride tanks for intermittent on-site H2 production by electrolysis (windmills, solar photovoltaics), or reformers, or intermittent supply by trucks
- Metal hydride compressors using waste heat

and

- Cryogenic carbon-based or MOF adsorption tanks at 77K temperature and moderate pressure (<100 bars) as intermediate solution between high pressure compressed gas cylinders, and LH2 tanks at 20K

and

- Disposable chemical hydride cartridges for portable micro-fuel cells
- Chemical hydride generators for sites with no local production of H2, when logistics in compressed gas cylinders, tube trailors, or LH2 tankers is prohibitive because of transport cost, or safety