



# Hydrogen Society

## Goal and Japanese strategy for realisation

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“(r)Evolution in Energy Economics”  
Estonian Academy of Sciences, Tallinn 8.5.2015

## Hydrogen Society, goal and Japanese strategy for realisation

- Why Hydrogen ?
- Why Society ?
- Why Japan ?
- Realisation – how ?

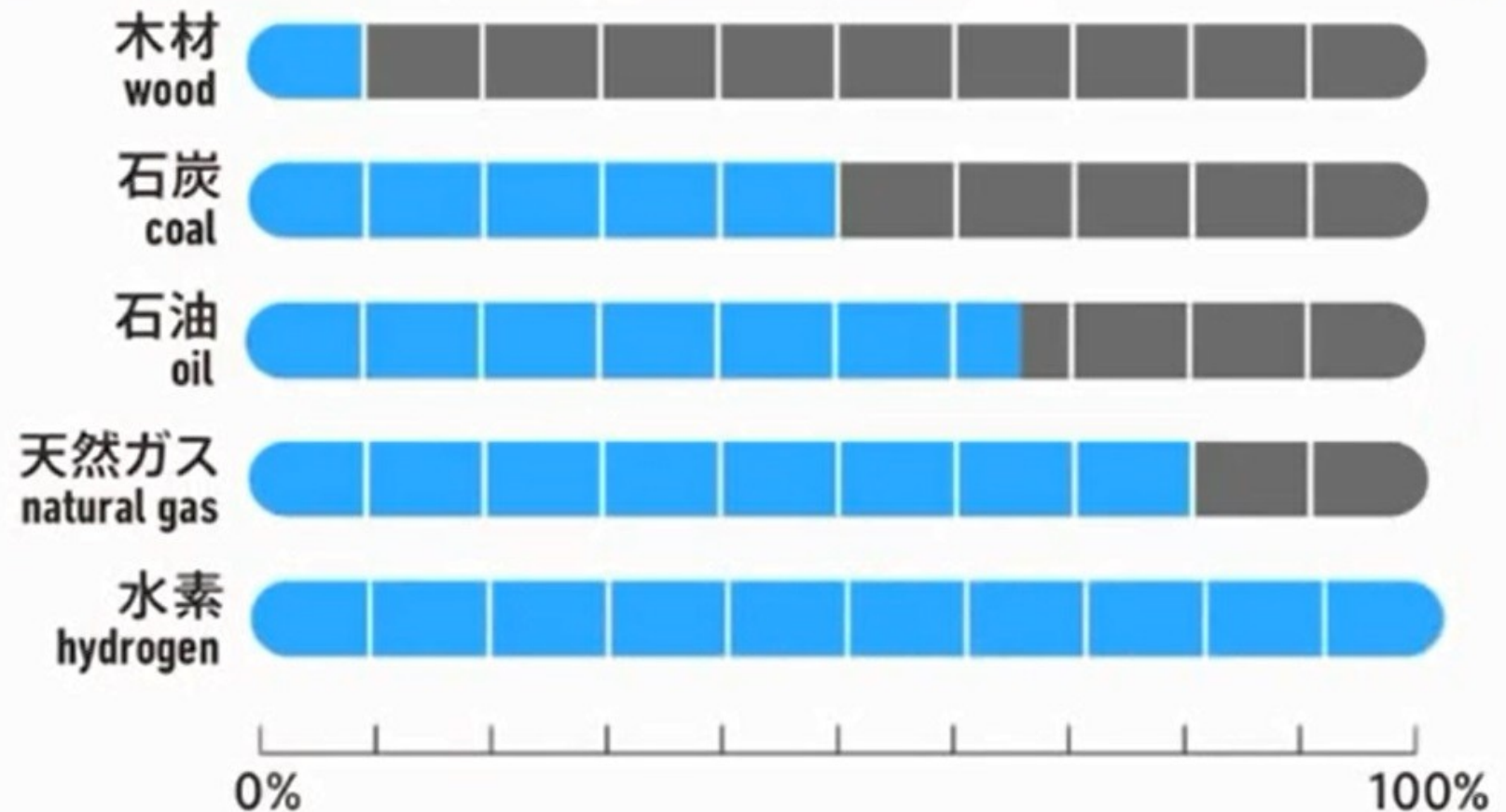


# The shift to Hydrogen

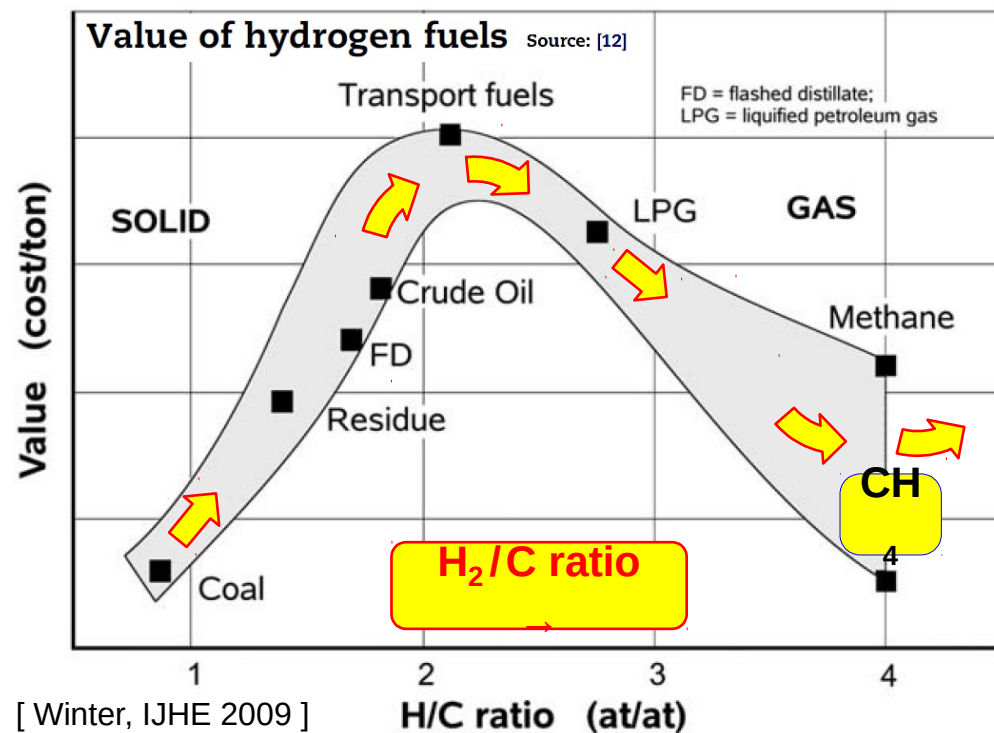
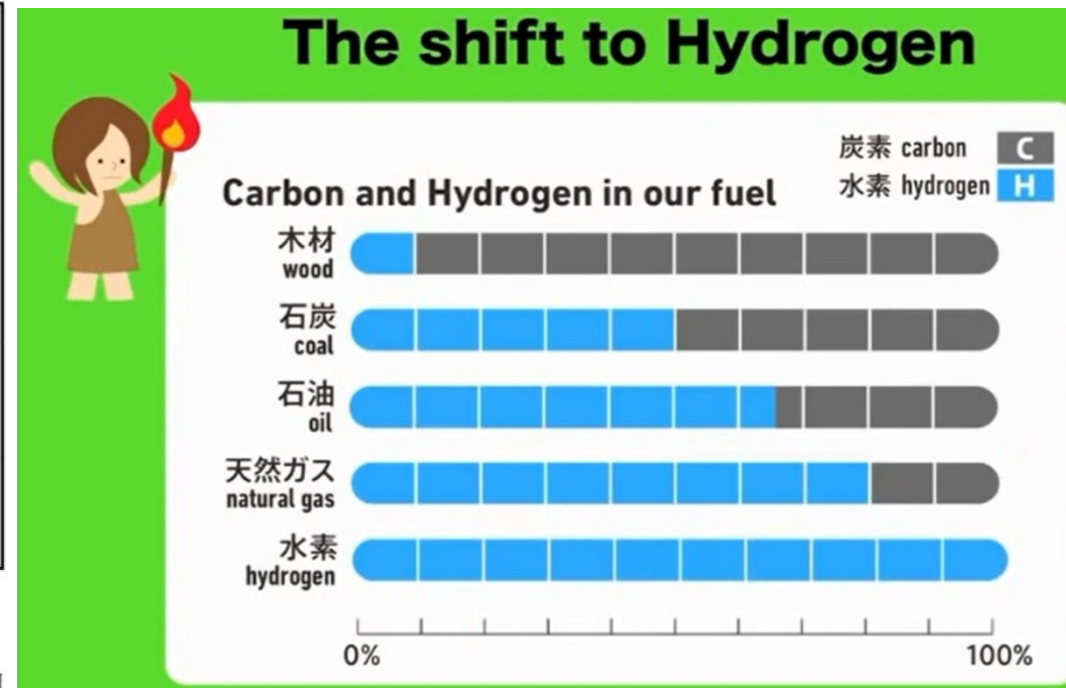
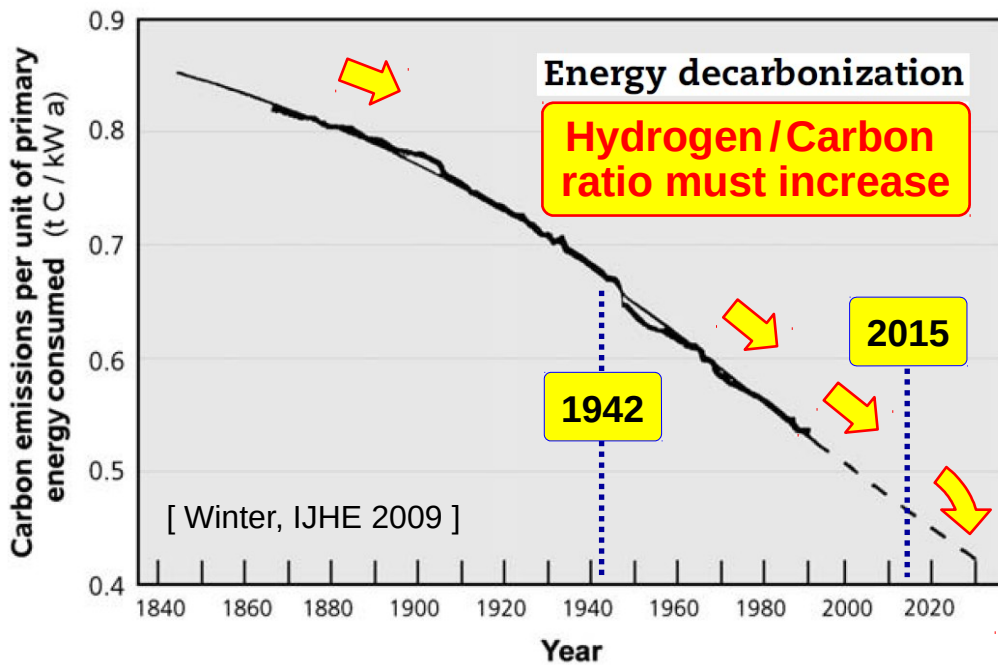


## Carbon and Hydrogen in our fuel

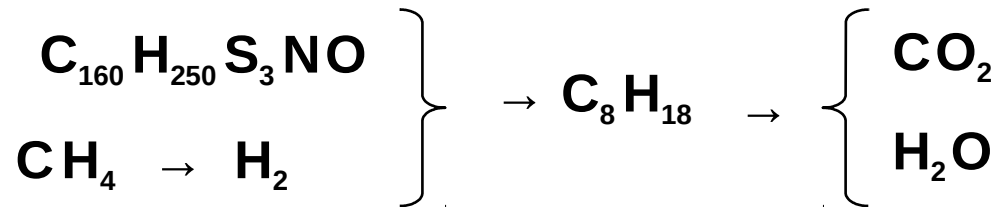
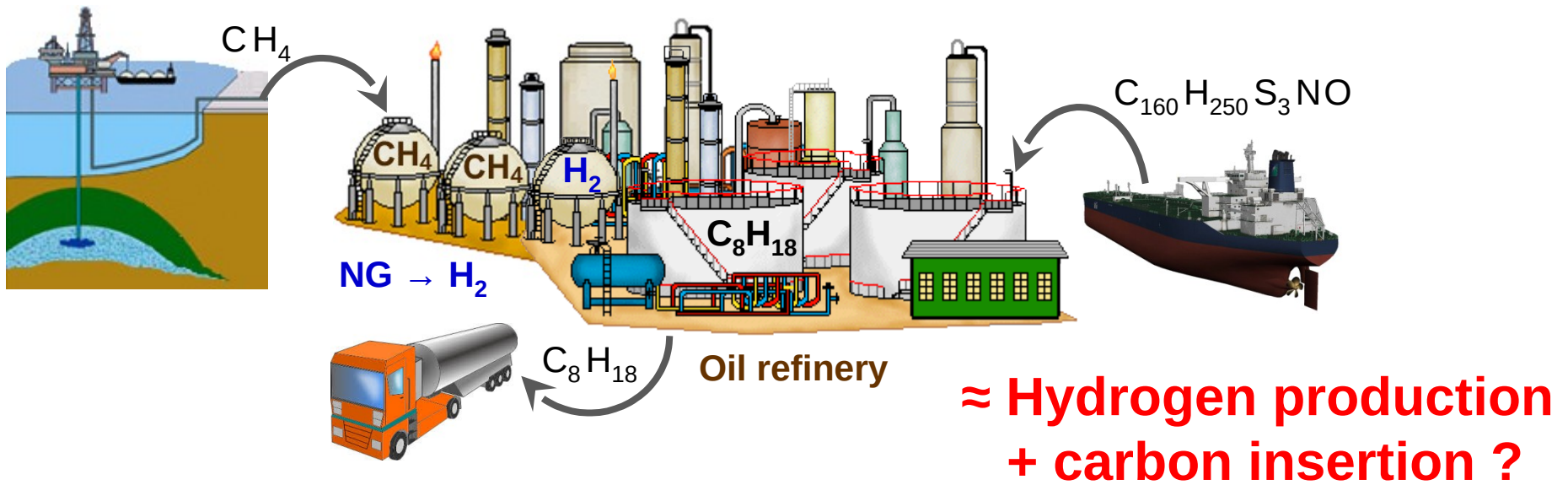
炭素 carbon **C**  
水素 hydrogen **H**







The only way is forward  
– toward the  
**Hydrogen Society**



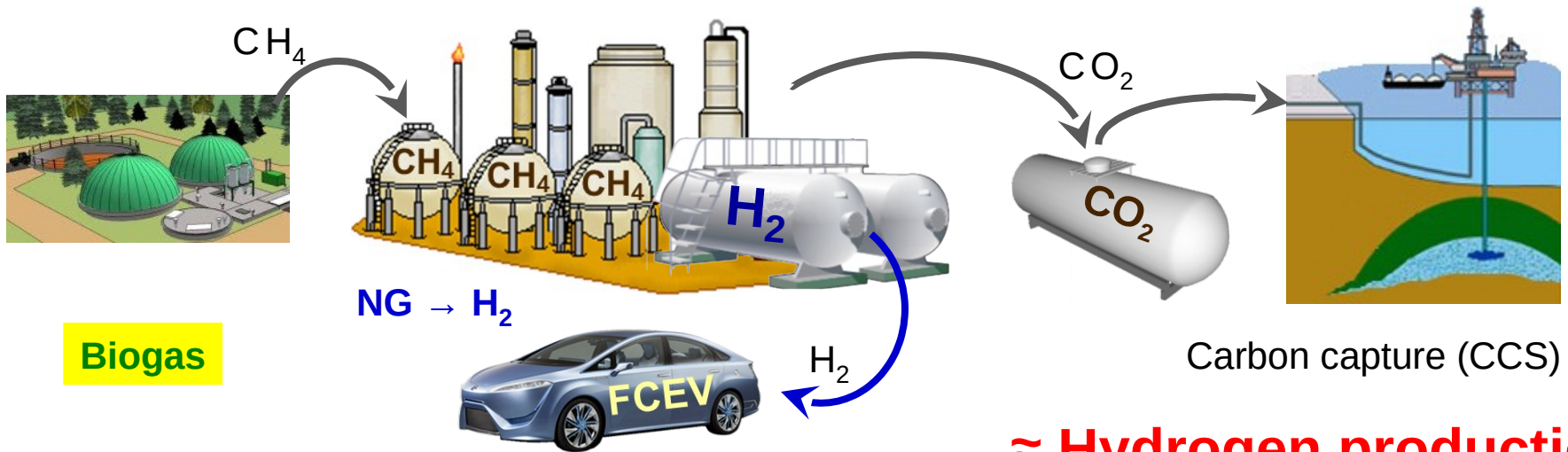
NG reforming:  $\text{CH}_4 + 2 \times \text{H}_2\text{O} \rightarrow 4 \times \text{H}_2 + \text{CO}_2$

Oil refining:  $\text{C}_{160}\text{H}_{250}\text{S}_3\text{NO} + 56 \times \text{H}_2 \rightarrow 20 \times \text{C}_8\text{H}_{18} + 3 \times \text{S} + 0,5 \times \text{N}_2 + \text{H}_2\text{O}$

Driving:  $20 \times \text{C}_8\text{H}_{18} + 250 \times \text{O}_2 \rightarrow 160 \times \text{CO}_2 + 180 \times \text{H}_2\text{O}$

(Real processes are complex)

# Hydrogen refinery



**$\approx$  Hydrogen production  
+ option for  
carbon capture ?**

## ***Pre-combustion CCS:***

*No hydro-carbons to customers*

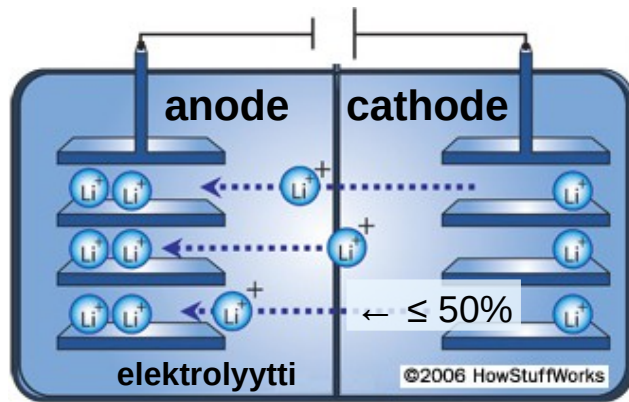
*$\rightarrow$  100 % green town*

*CCS realized by big companies*

*$\rightarrow$  global actors & government*

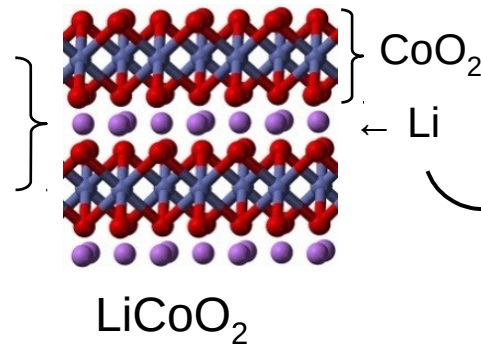
# Energy carriers for electric cars

Li battery  $\approx 1$  electron /  $\gg 200$  proton + neutron

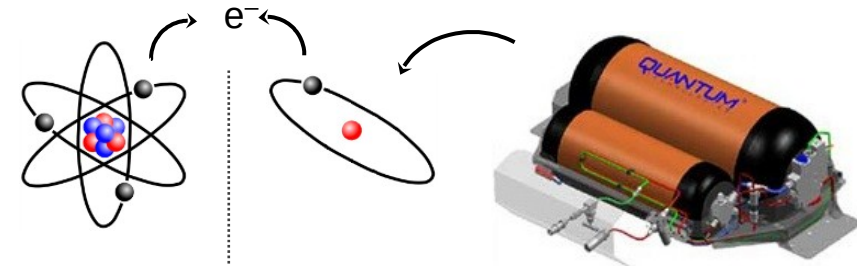


## Lithium Cobalt oxide battery

Cathode mass  $\geq 196$  / electron  
+ anode, electrolyte, cooling, ...



$\text{H}_2 \approx 1$  electron / 1 proton



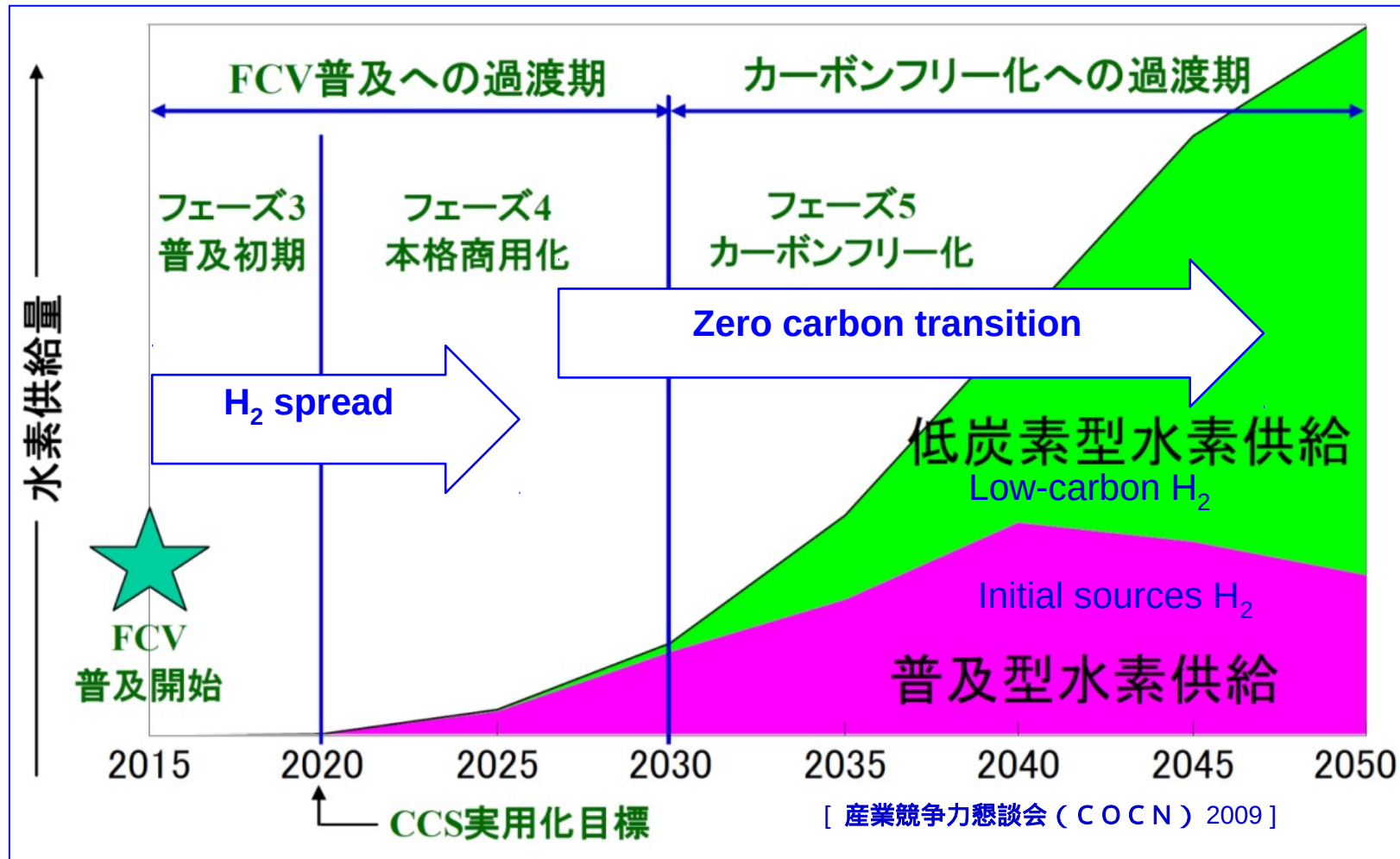
Hydrogen tank 700bar

$\text{H}_2$  mass = 1 / electron  
+ tank, fuel cell, ...

Toyota tank: 83kg @ 5kg  $\text{H}_2$   
→ 5,7 w% density

# Strategic approach for decarbonisation

1. Introduce and commercialise applicable energy carrier = hydrogen, ...
2. Develop low carbon processes based on this energy carrier



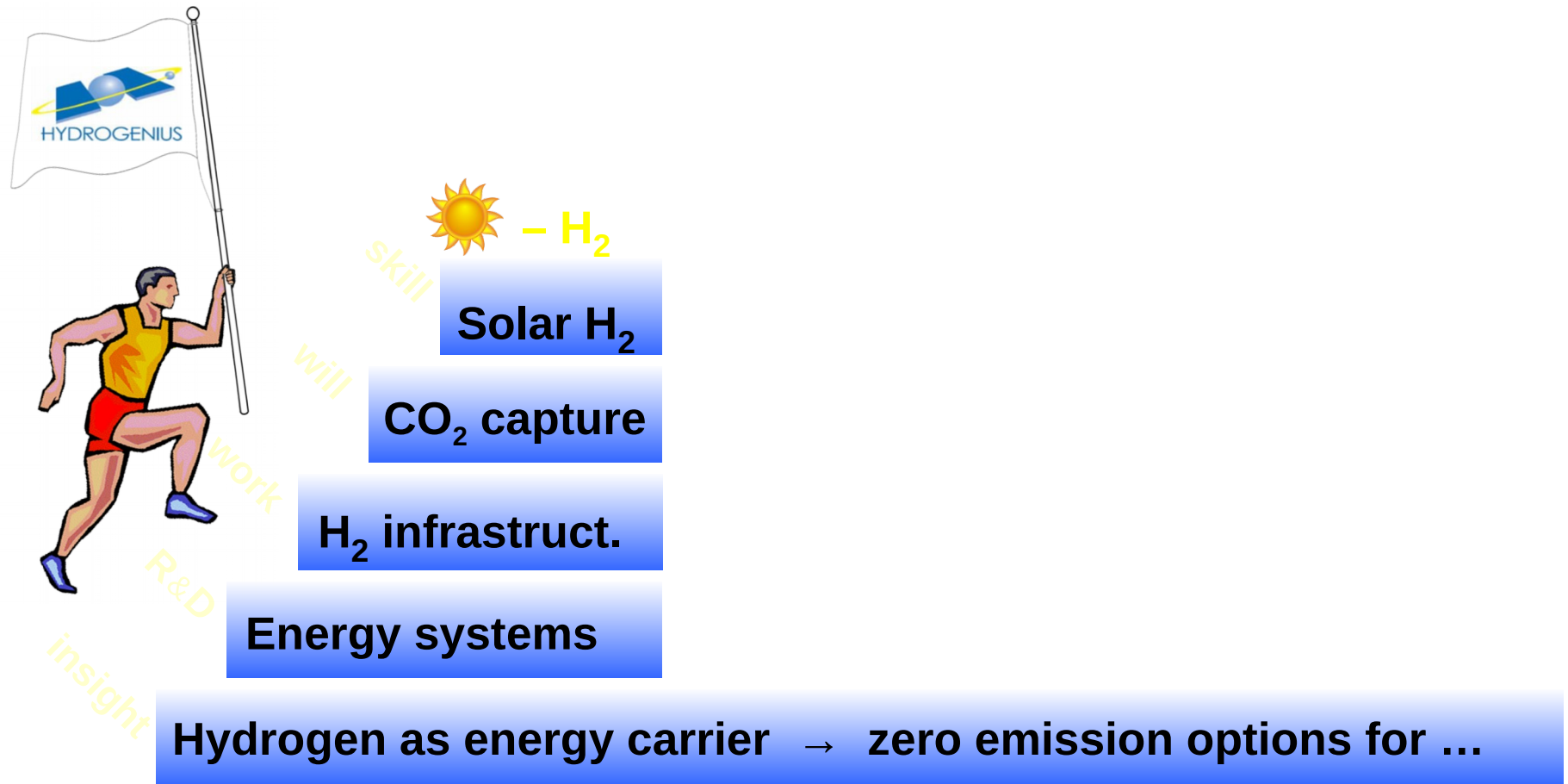


# Step 1 – define and build a basement

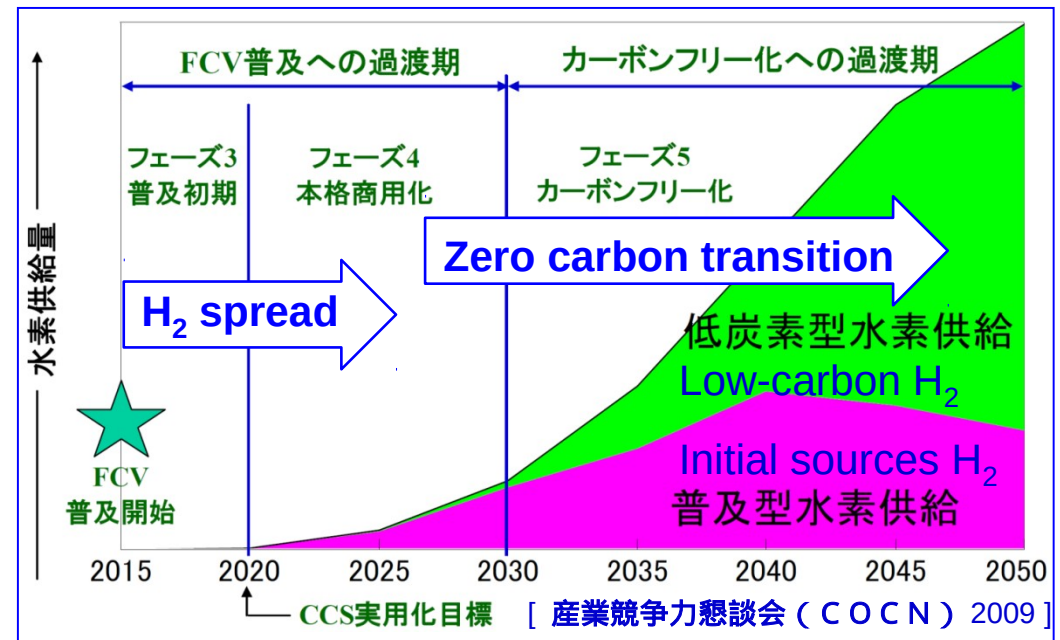
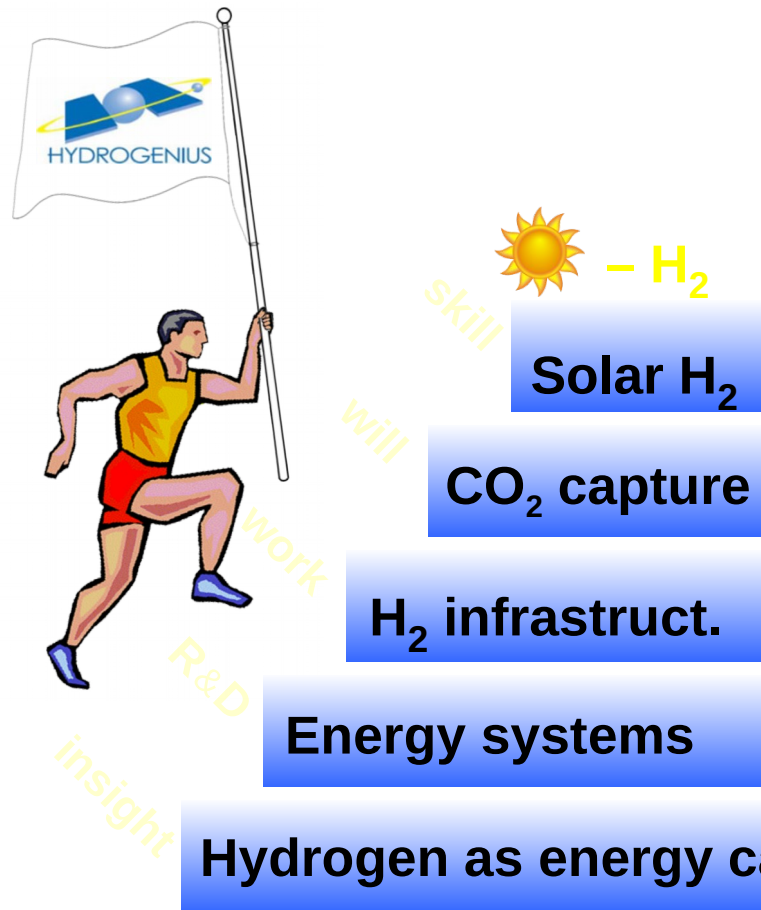
*insight*

**Hydrogen as energy carrier → zero emission options for ...**

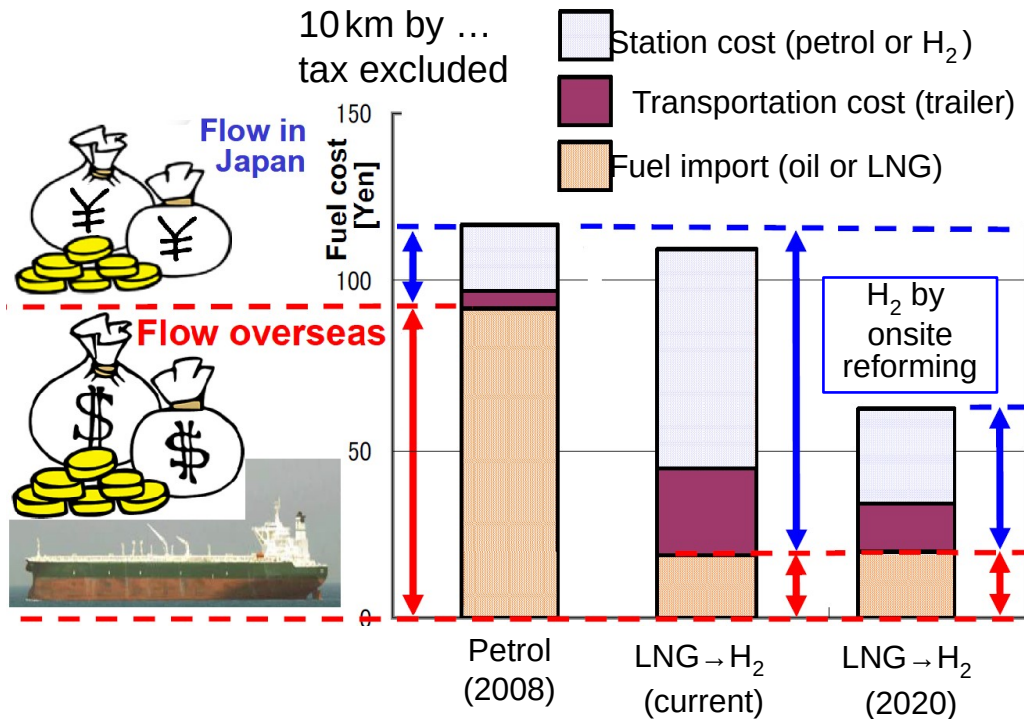
# Steps to Hydrogen Society



# Steps to Hydrogen Society & decarbonisation

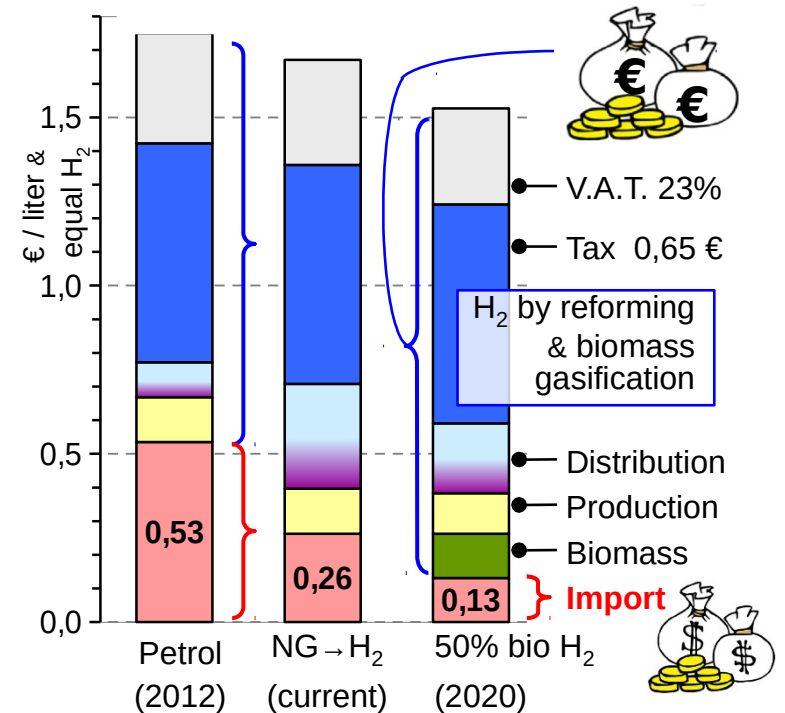


## Calculation in Japan



[ extracted from T. Kawai / Toyota, H<sub>2</sub> forum 2012 ]

## Calculation in Finland



[ Neste Oil annual report 2011 + VTT estimates ]

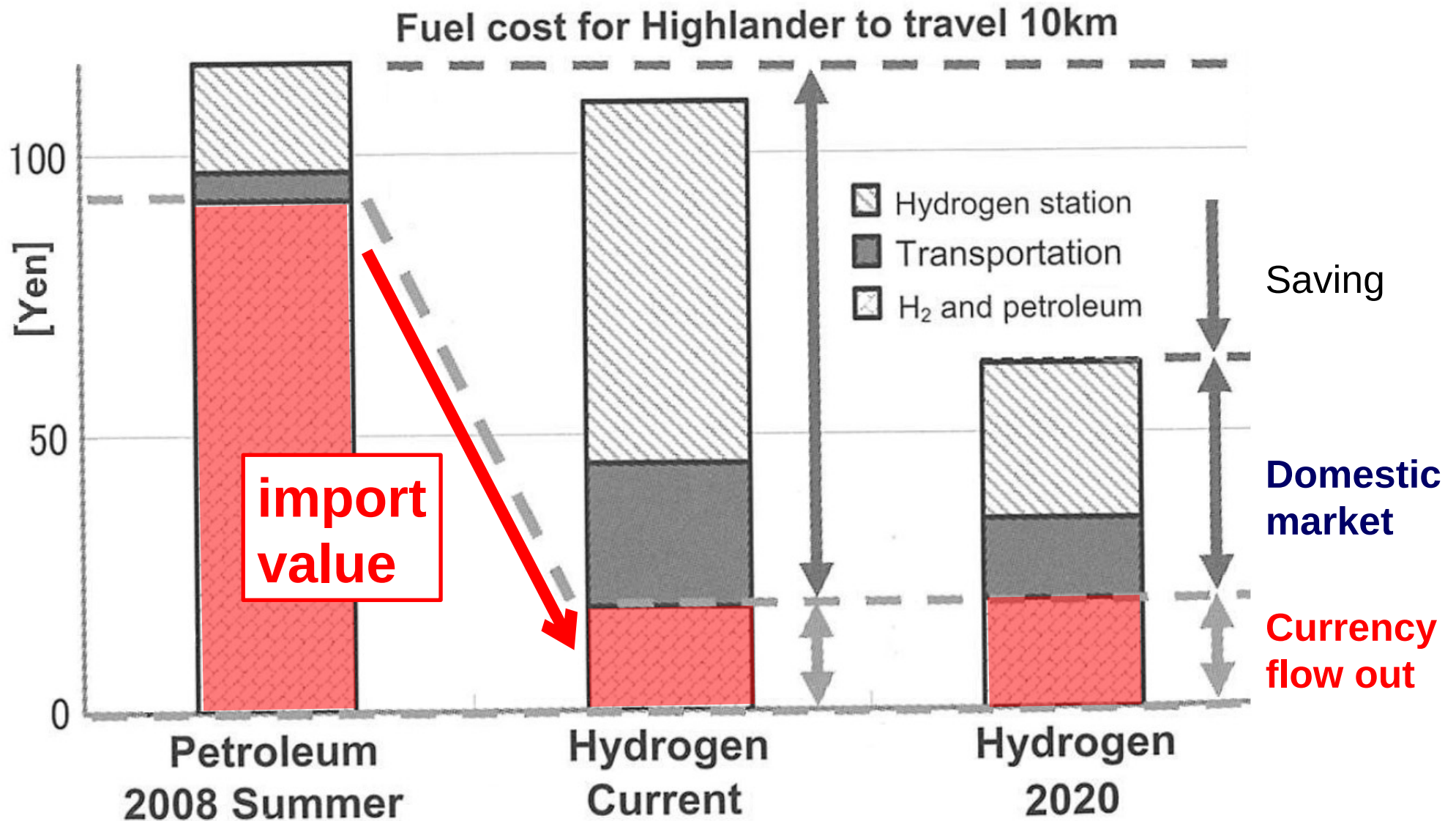
**FCV's are needed!**

**Biomass gasification:**

- low emission
- low import



# Value of energy import for transport



## Acceleration of steps toward realization of a “hydrogen society”:

... “Therefore, hydrogen, which can achieve **high energy efficiency**, low **environmental** burden and capability for **emergency use** provided appropriate usage, is expected to play a **central role** for secondary energy sources.”

## Formulating a road map toward realization of a “hydrogen society”:

... “Realizing a hydrogen society is a **grand project** that can be carried out only if GOJ and municipalities are proactively involved in it as major players of the new society in addition to infrastructure-related companies and oil, city gas and LP gas suppliers as well as manufacturers of products using hydrogen and related technologies and equipment.”

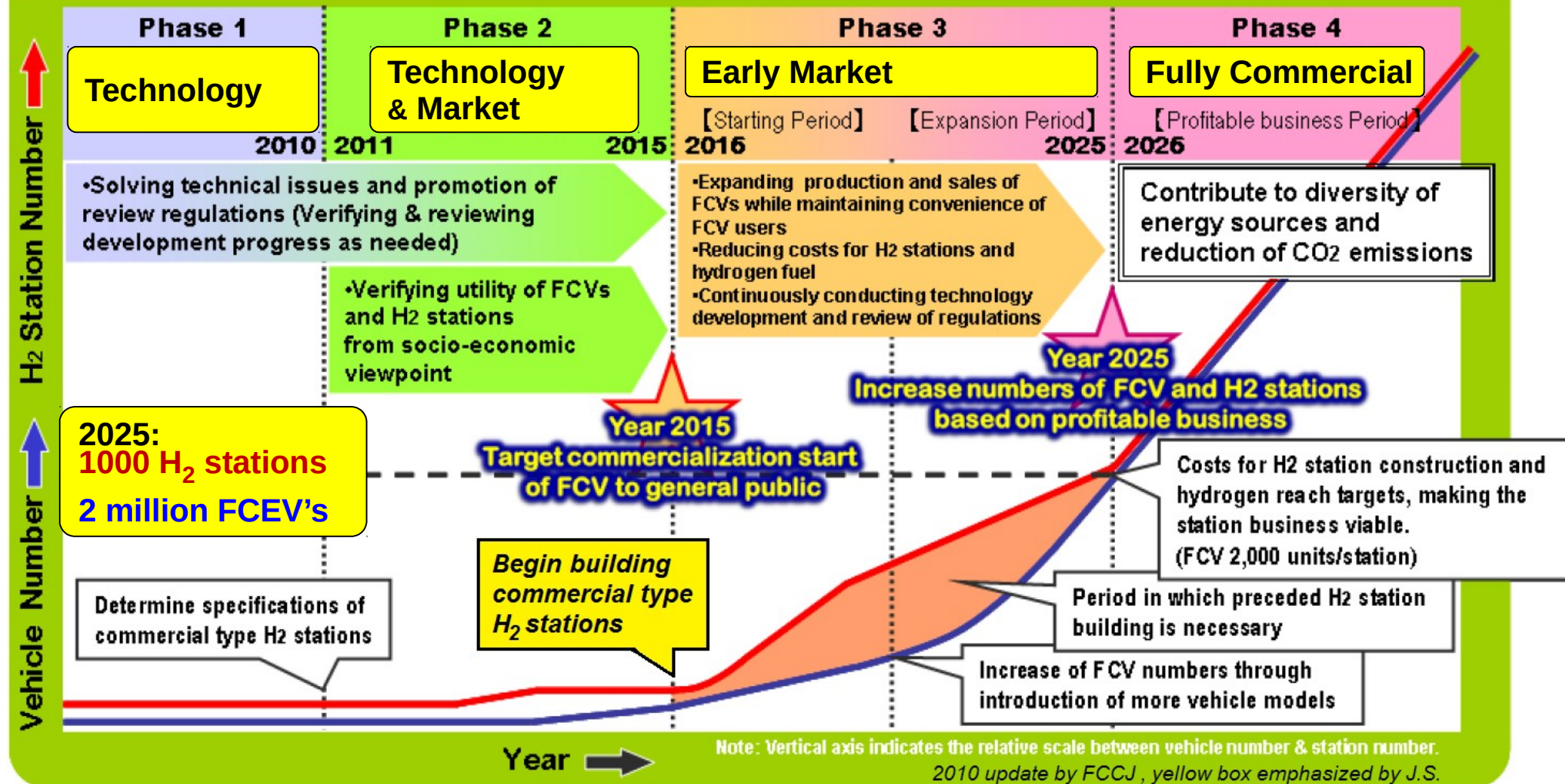
## **Release onto the market:**

- Residential fuel cells in 2009;
- Fuel cell vehicles in 2015
- 2017 Releasing fuel cells for commercial and industrial use onto the market

## **Price of hydrogen & FCEV:**

- Around 2020 Achieving a reduction of hydrogen price to a level equal to or lower than that of fuels for hybrid vehicles.
- Around 2025 Fuel cell vehicles: Achieving a reduction of vehicle prices to the level of hybrid vehicles of the same class and price range
- (2015 hydrogen price is about equal to gasoline)

## Commercialization Scenario for FCVs and H<sub>2</sub> Stations



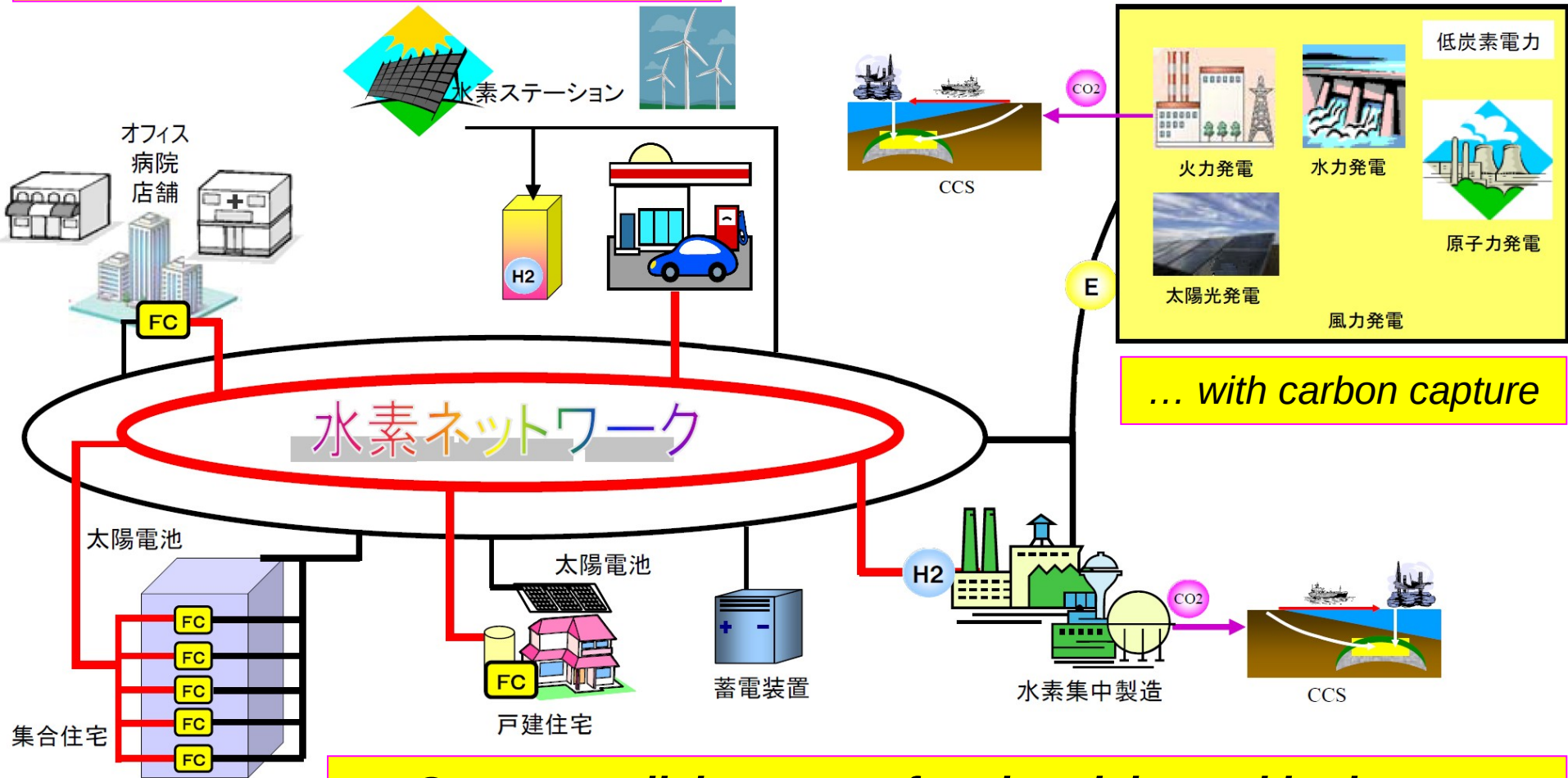
\* Precondition: Benefit for FCV users (price/convenience etc.) are secured, and FCVs are widely and smoothly deployed



# Hydrogen Society – a strategic goal

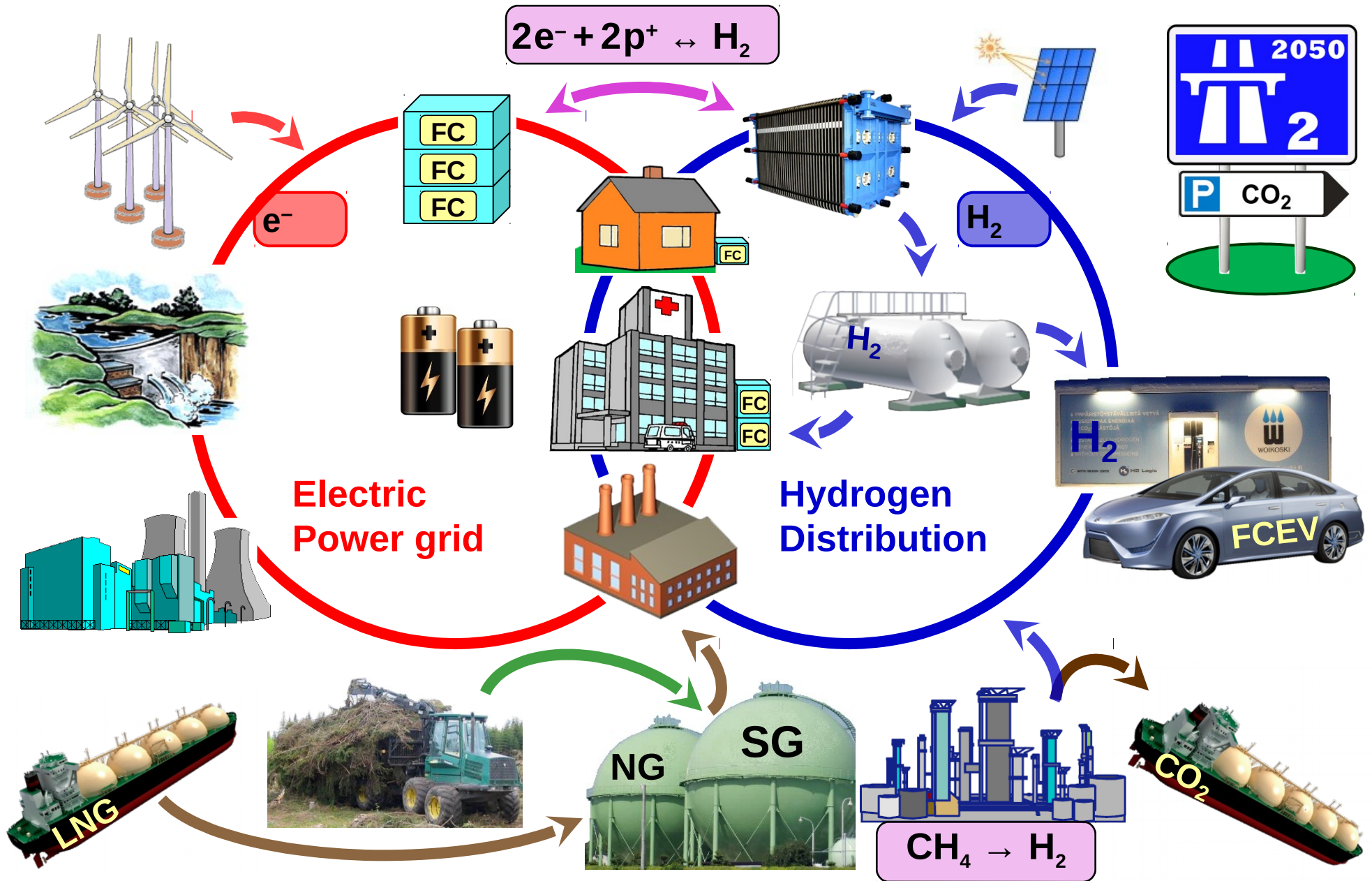
## Distributed energy & H<sub>2</sub> storage

## Centralized energy

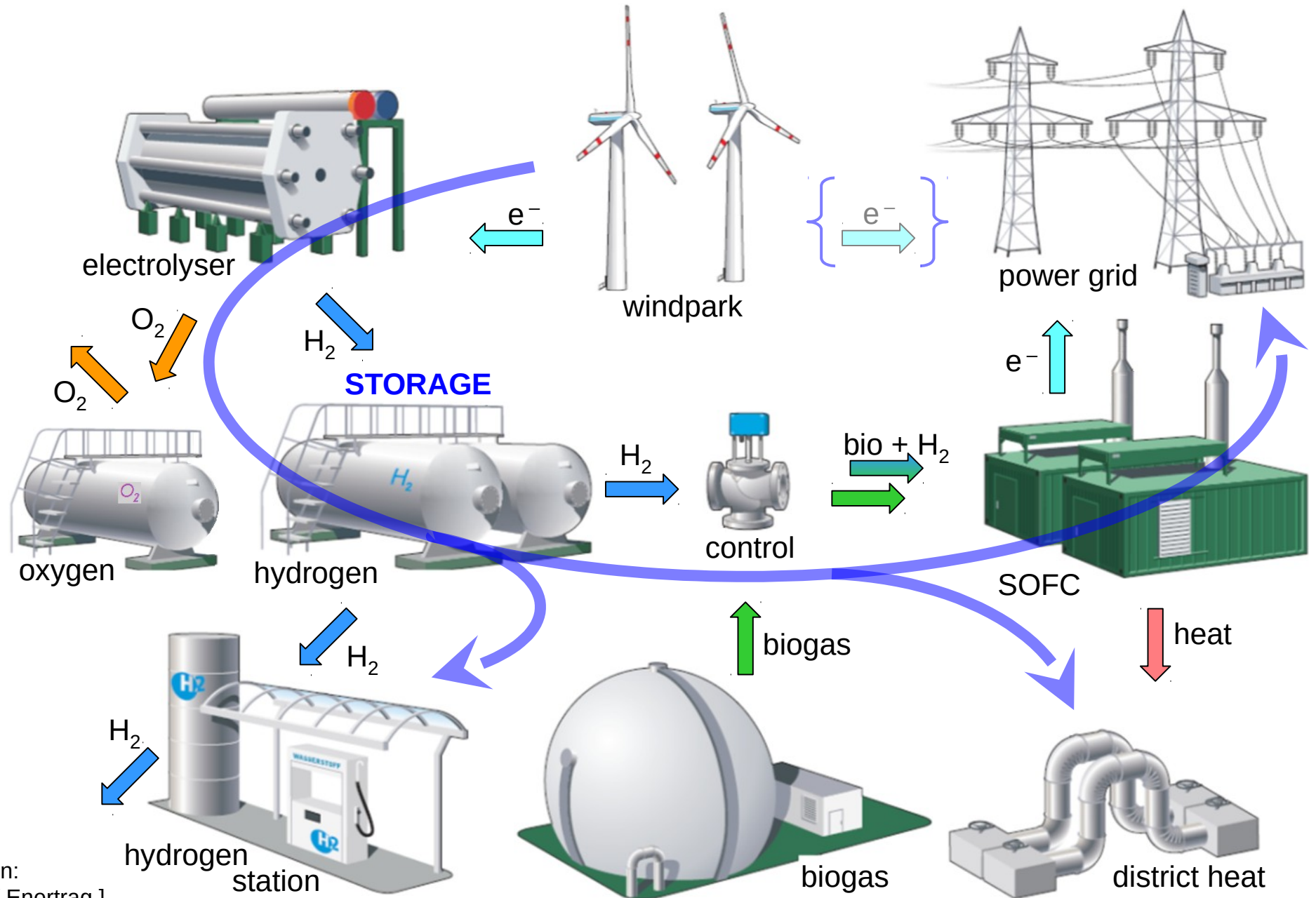


**Smart parallel systems for electricity and hydrogen**

# Hydrogen Society



# Hydrogen loop for power balance







**Forging of Sampo, the source of prosperity**  
[ Akseli Gallen-Kallela, 1893 ]



[ JHFC ]



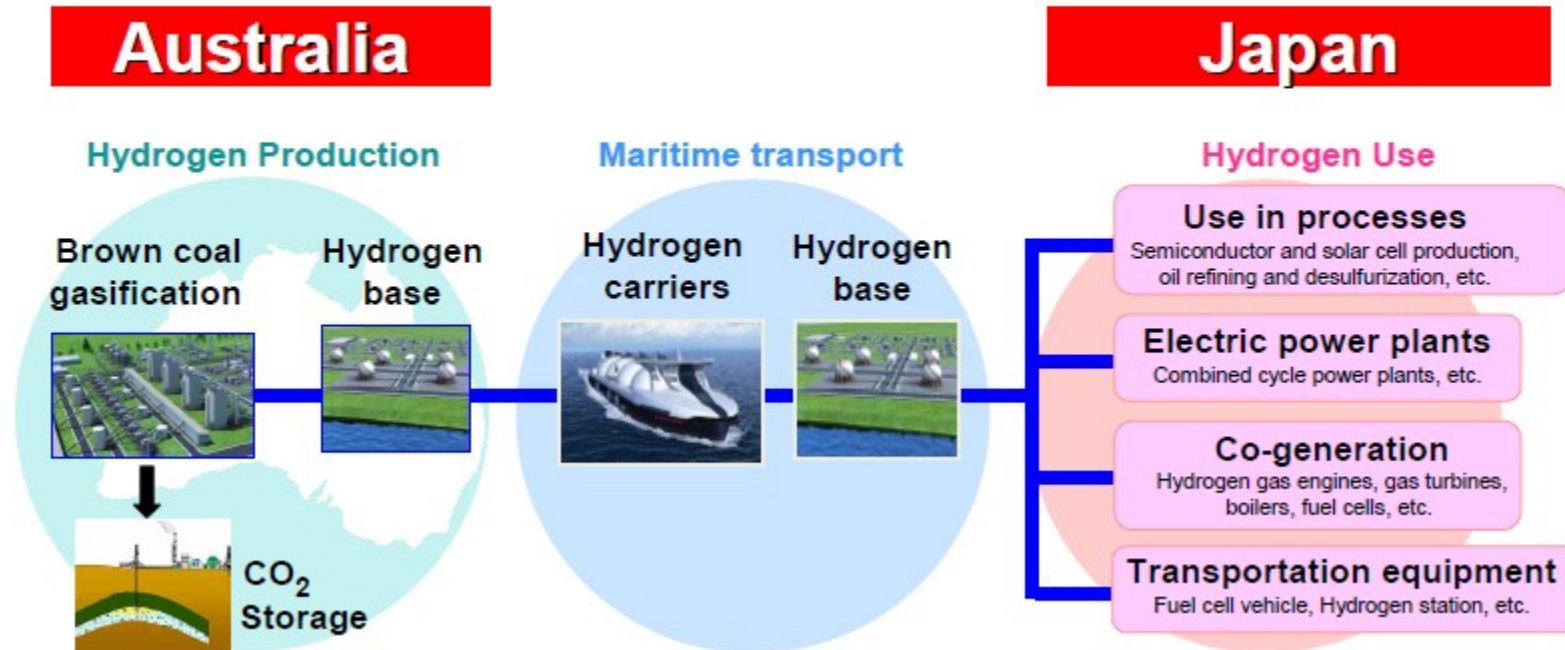
# Hydrogen Society – for next generation

## Hydrogen Energy and Advanced Technology Exhibition (2008 & 2009)



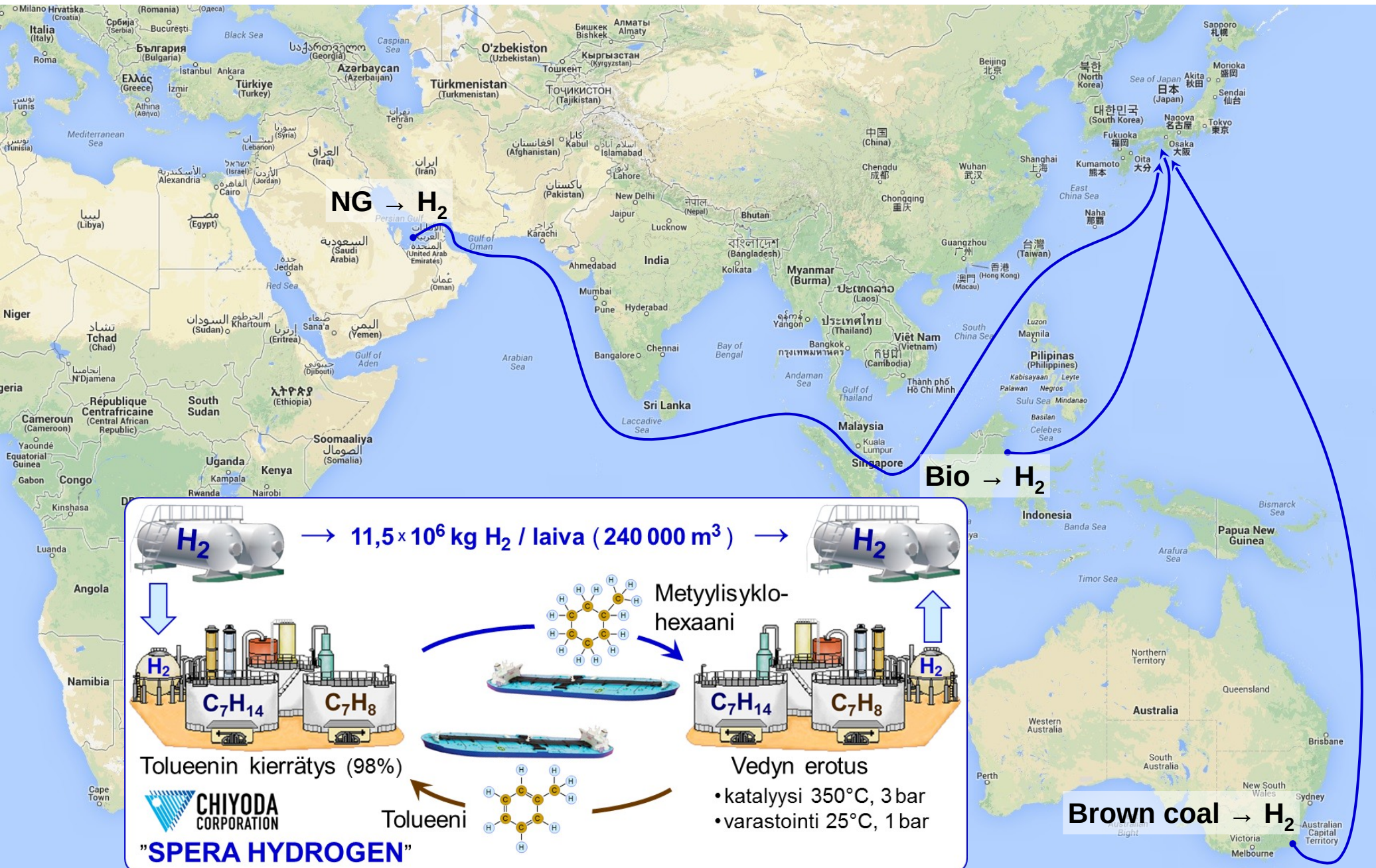


## CO<sub>2</sub> free hydrogen chain



- First liquid hydrogen tanker departs **in 2017** from Australia to Japan.
- Feasibility study for polar route from Norway has been done, ...
- "production of liquid hydrogen by utilizing geothermal power is about to kick off on the volcanic island of Iojima" [Japan News 3.5.2015]

# Diverse energy sources → Oil independency





# Hydrogen Town





# Hydrogen Town

