
Who changees the world

International Institute for Carbon-Neutral Energy Research

I²CNER

Hydrogen together with Winds play an Important Role in the coming Low Carbon Sustainable Society

Wind meets Gas

17th Oct. 2019 Groningen

WPI Visiting Professor

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KYUSHU UNIVERSITY

wpi World Premier International Research Center Initiative

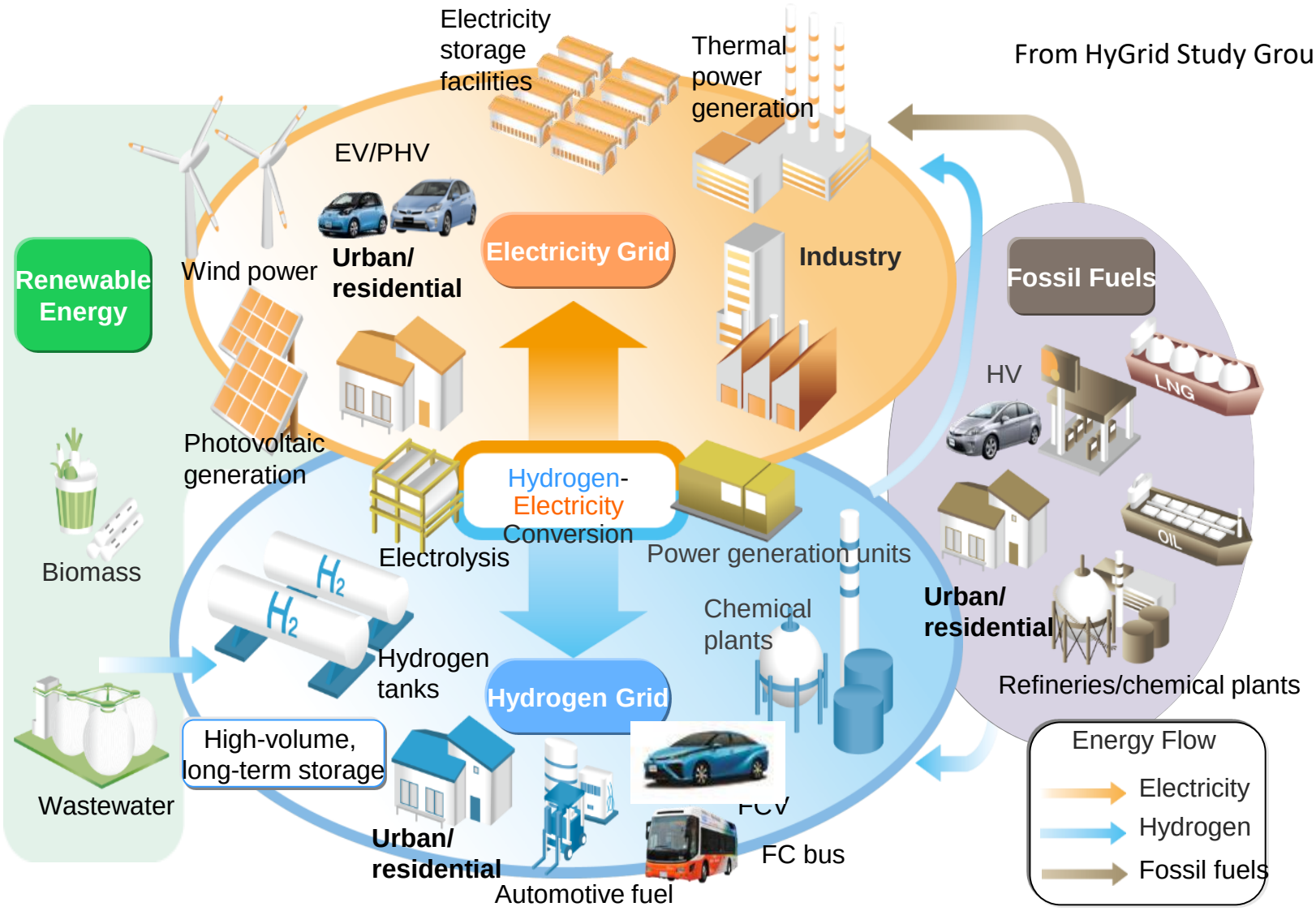
ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Holy Trail of Chasing Hydrogen

Netherland &me

Future Energy System HyGrid (Hybrid Grid)

Maximum Use of Renewable and Optimum Use of Fossil



European Commission

The EU Energy System

53%
of EU energy imported in 2014

€400 billion
spent on energy imports in 2014

6
Member States depend on a single external supplier for their entire gas imports

75%
of EU housing stock is energy inefficient

94%
of EU transport relies on oil products (of which 90% imported)

30%
EU wholesale electricity prices higher than US

4.4%
rise in EU household electricity prices 2012-2013

€1 trillion
investments into the EU energy sector needed by 2020

€120 billion
per year spent on energy subsidies (directly or indirectly)

€129 billion
annual turnover of EU renewable energy businesses

Source: EU Commission Communication on "A framework Strategy for a Resilient Energy Union with Forward-Looking Climate Change Policy", 25 February 2015.

CLIMATE POLICY OBSERVER
monitoring climate policies

Research and Innovation

Hydrogen can help mitigate all these challenges

Enable the renewable energy system → Decarbonize end uses

Enable **large-scale renewables integration** and **power generation**

Distribute energy across sectors and regions

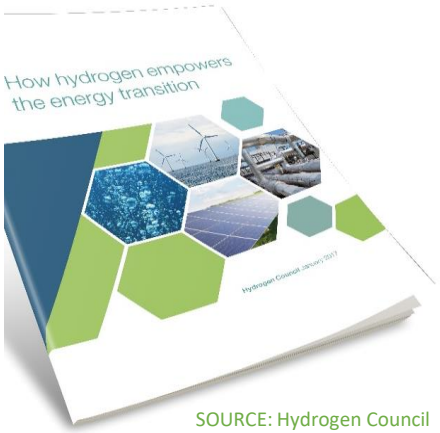
Act as a **buffer** to increase system resilience

Decarbonize **transportation**

Decarbonize **industrial energy** use

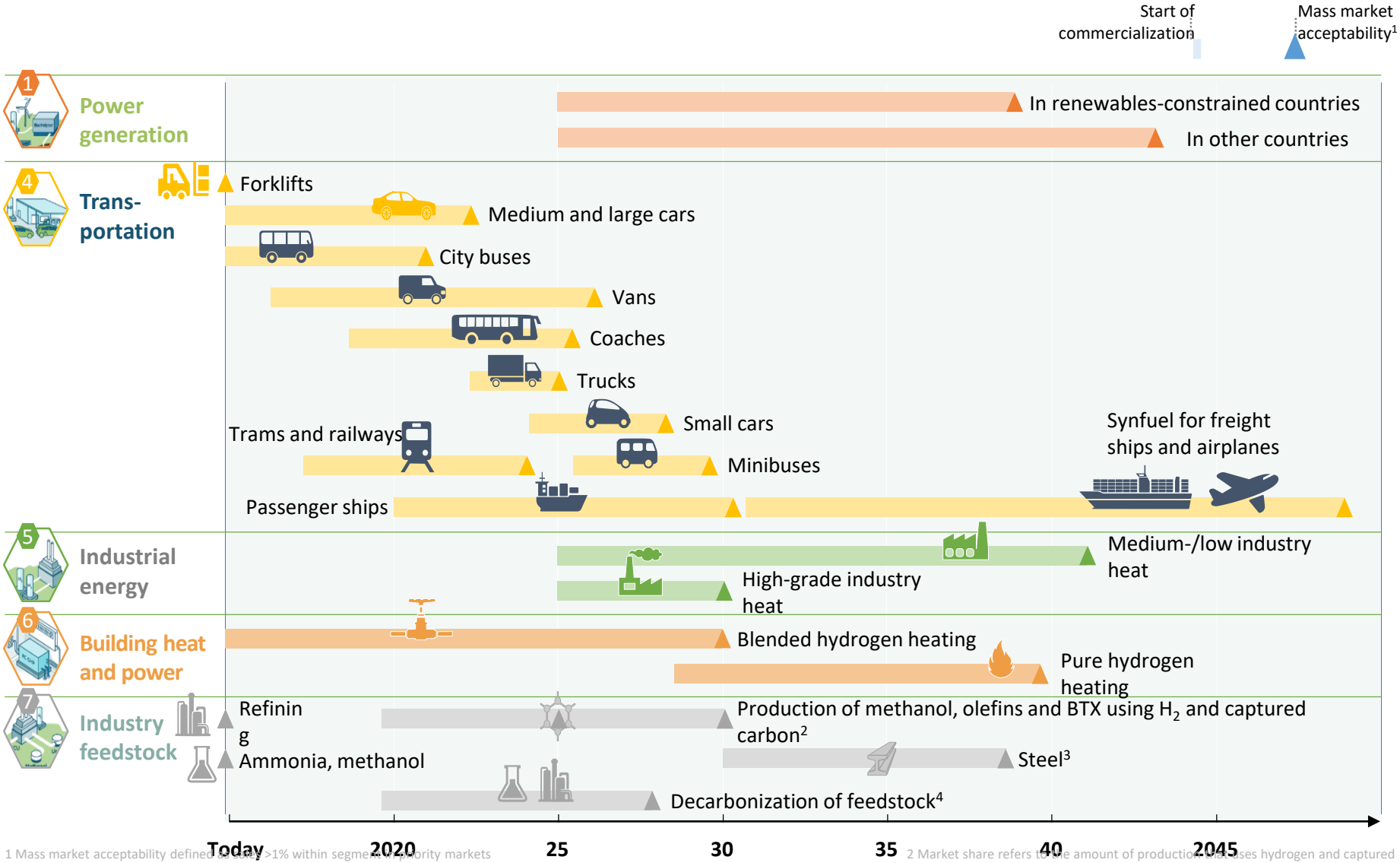
Help decarbonize **building heat and power**

Serve as renewable **feedstock**



SOURCE: Hydrogen Council

Hydrogen for transport Roadmap



1 Mass market acceptability defined as >1% within segment / priority markets

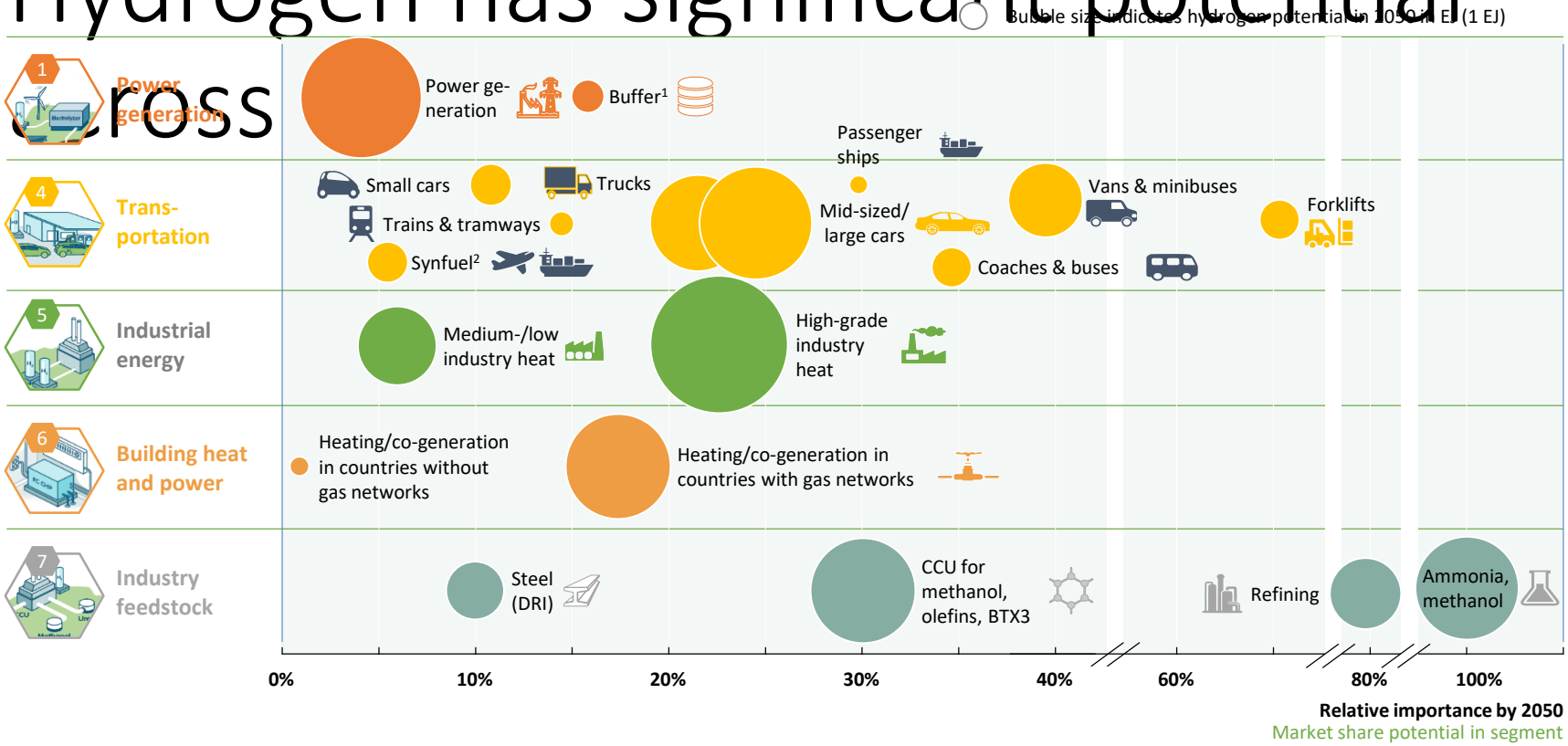
2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock

3 DRI with green H_2, iron reduction in blast furnaces and other low-carbon steel making processes using H2 sources

4 Market share refers to the amount of feedstock that is produced from low-carbon sources

SOURCE: Hydrogen Council

Hydrogen has significant potential across



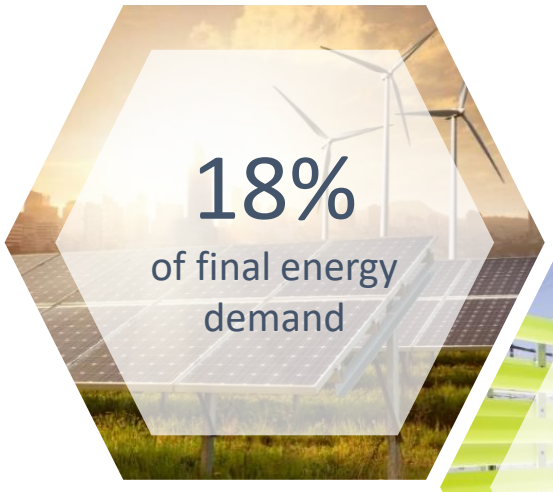
1 Percent of total annual growth in hydrogen and variable renewable power demand 2 For aviation and freight ships

3 Percent of total methanol, olefin, BTX production using olefins and captured carbon

SOURCE: Hydrogen Council

Estimated impact in 2050

Hydrogen can benefit the energy system, environment and economy



1 Value add of fuel cells

SOURCES: Hydrogen Council, IEA ETP Hydrogen and Fuel Cells CBS, National Energy Outlook 2016

Physics for Economy

Dr. prof. Katsuhiko Hirose

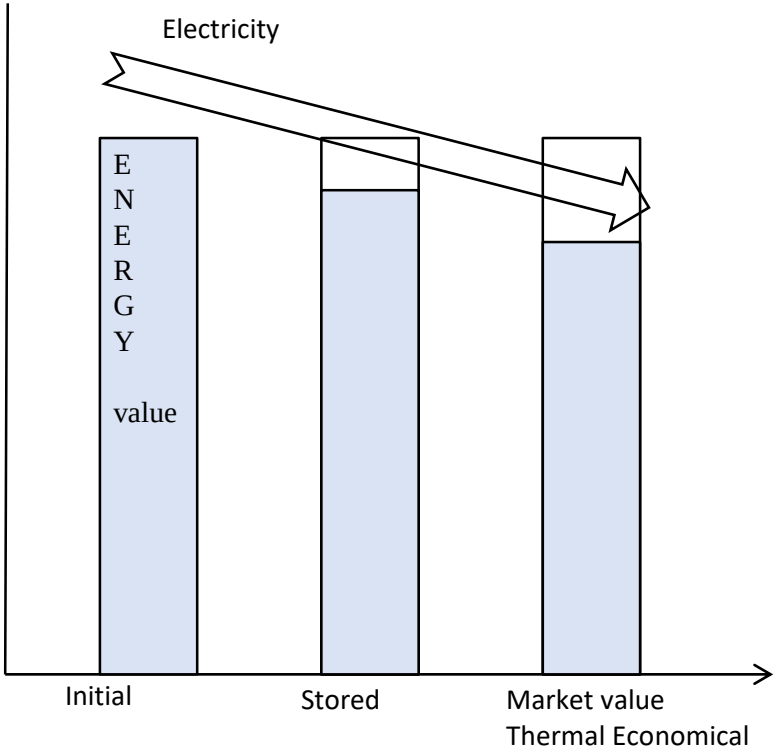
International Institute for Carbon Neutral Energy Research

Kyushu University

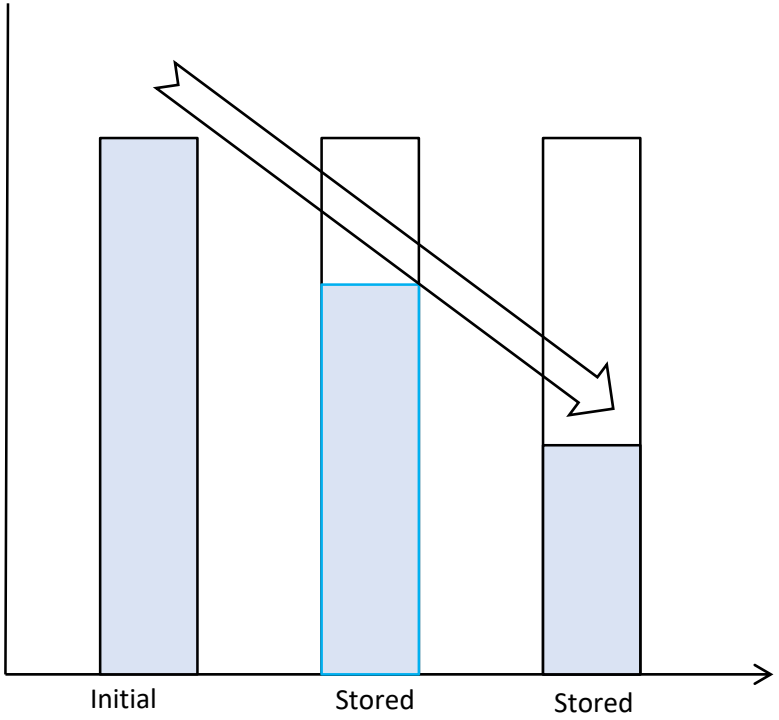
At Lausanne market

Market Value and energy Value

- Energy Efficiency of Battery storage and hydrogen Storage



Battery system



Hydrogen system

Milk to Cheese conversion

- Beef jerky conversion
  - Summer fresh beef

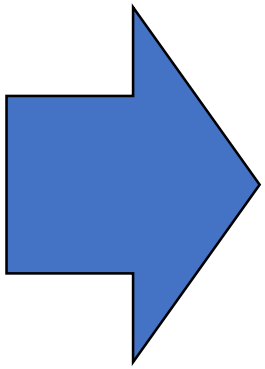
    -> Dry Beef (beef jerky)

  Eating in winter as a food

  Food to Food

FOOD Storage

- Milk Chees



Milk Cheese conversion

- Summer
- Cheap Milk to Cheese

- 3Values
- Create Product value
  - cheese is more expensive than Milk
- Time shift
  - Summer to other season
- Replacement value
  - Cheese compete expensive appetizer such as Salami, Caviar,

Milk Cheese Conversion Value created by triple values

Hydrogen
Storage such as Beef Jerky
or
Milk Cheese Conversion

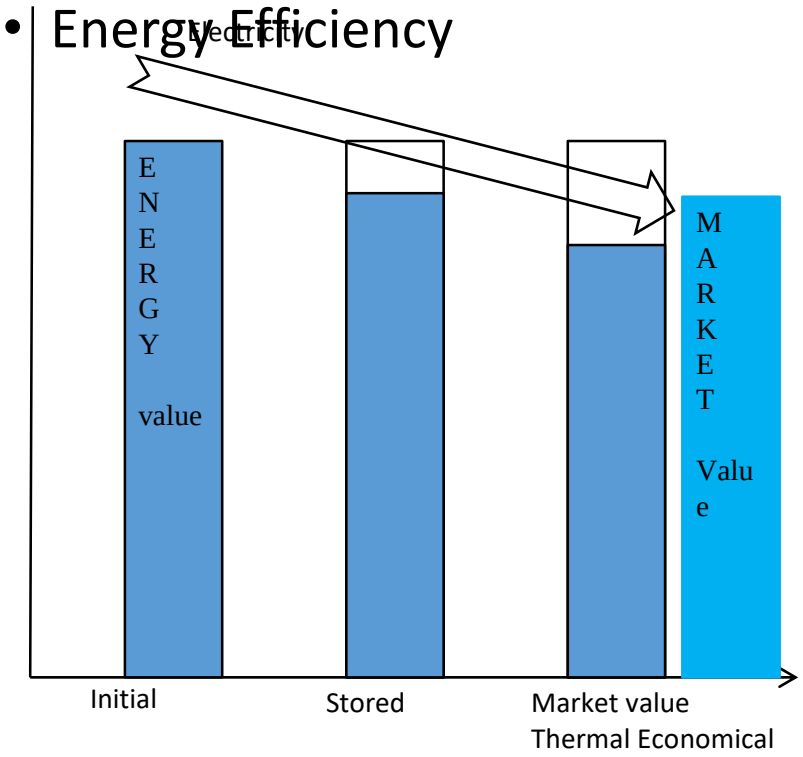
- Cheap electrons => Chemicals
- Time Shift
  - Wind Blow and Sunshine
  - =>>Dark windless seasons
- Replacement Values
  - Hydrogen Car reduce the expensive Oil
- Electrons -> Battery -> Electrons

Milk to Chees

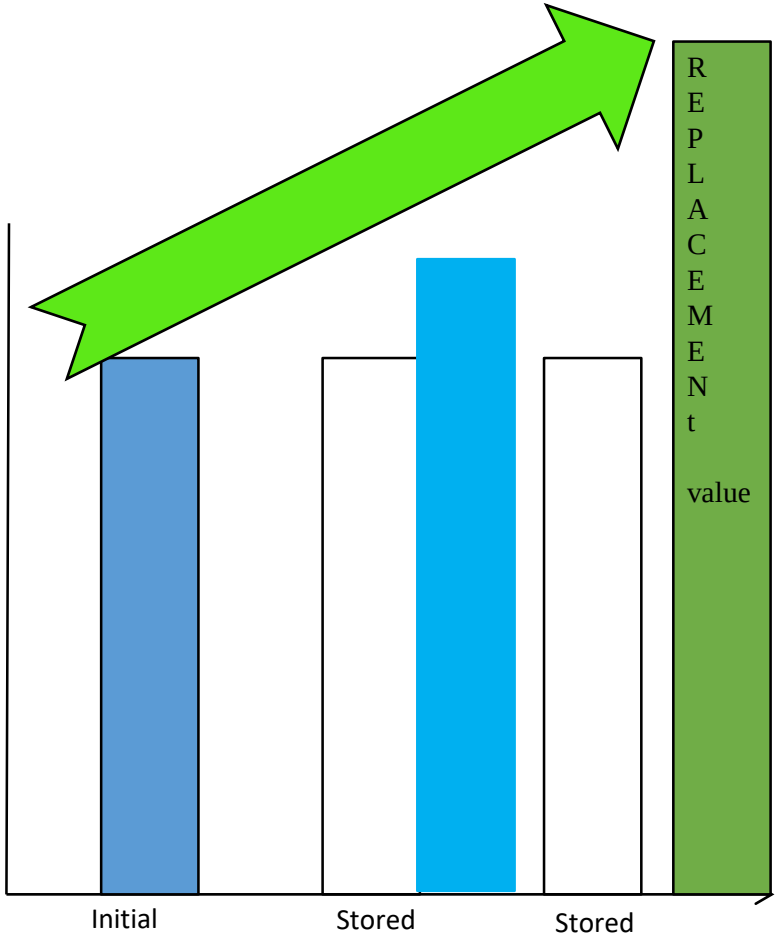
Beef to Beef jerky

Market Value and energy Value

- Energy Efficiency



Battery system



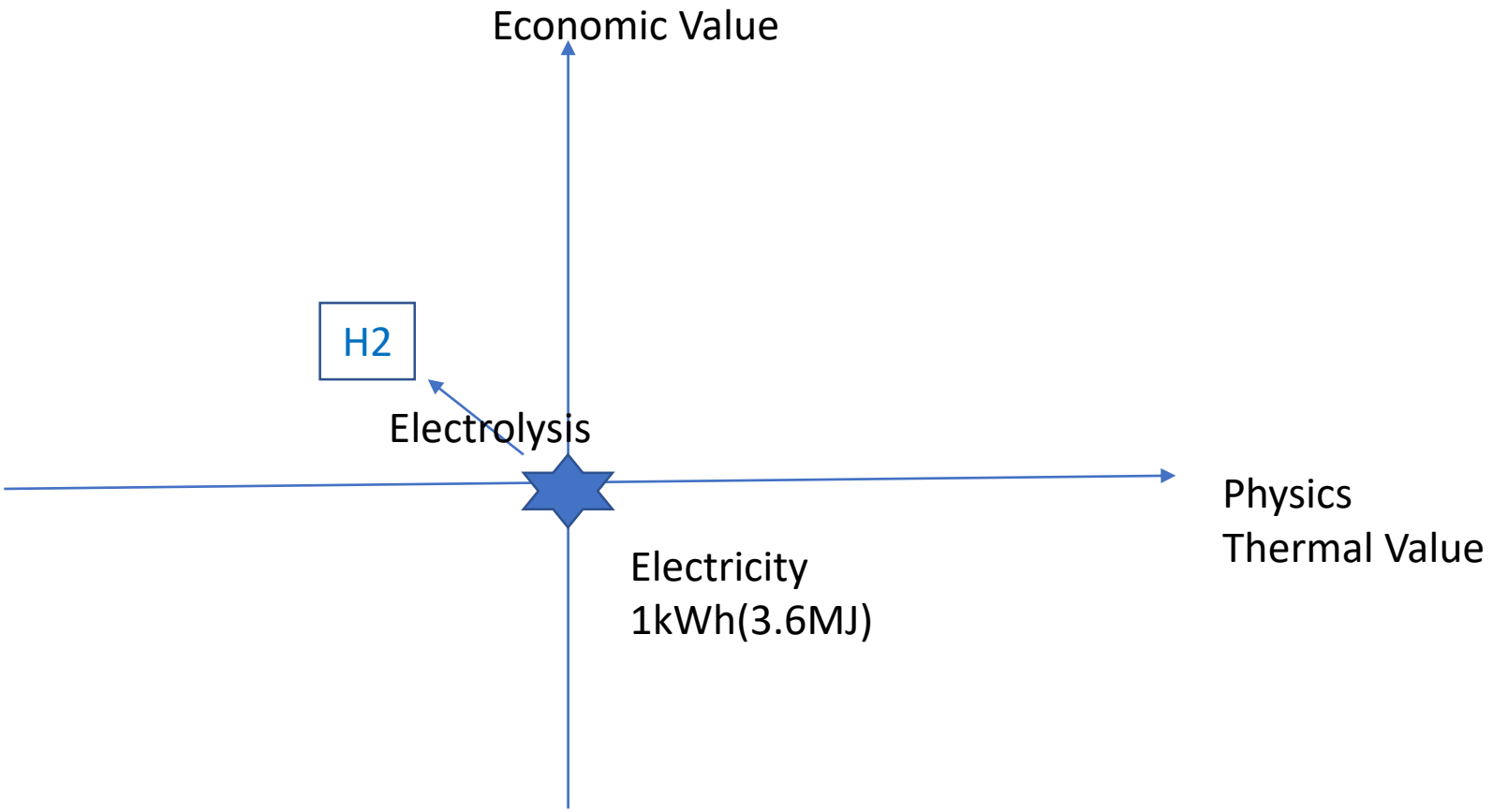
Hydrogen system

Hydrogen has more value than Energy Storage

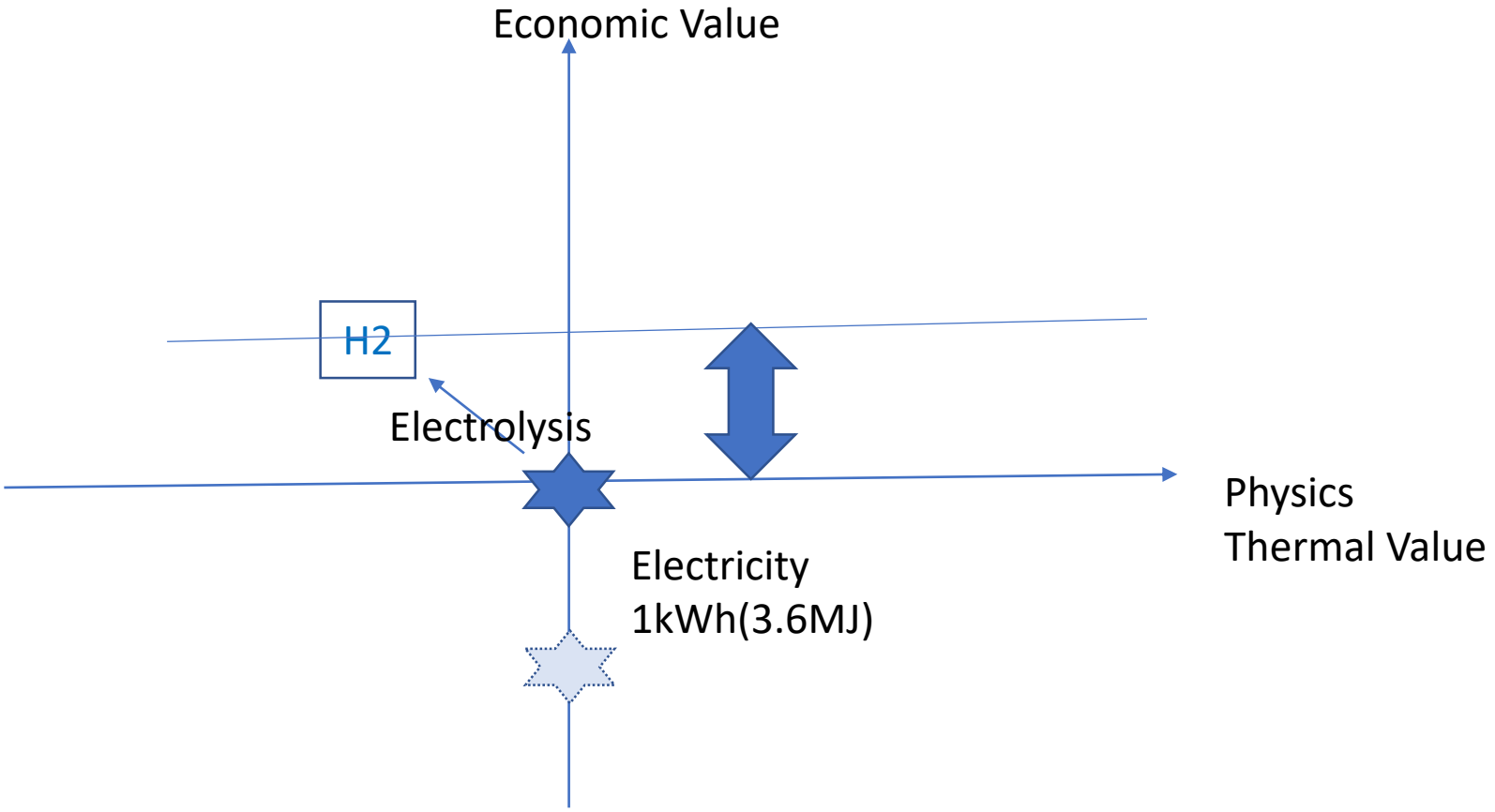
Through Milk Cheese Conversion

I propose to call

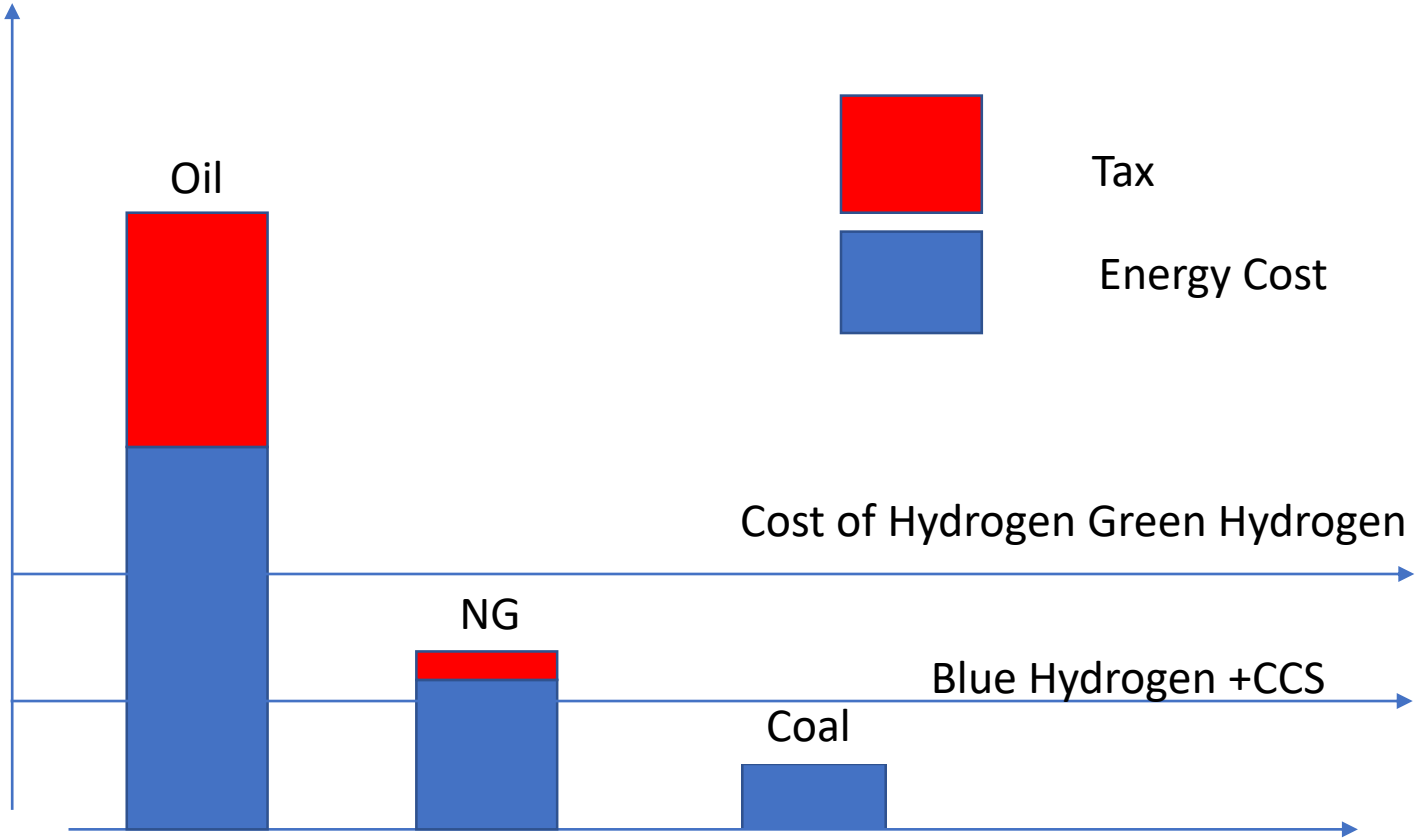
- Hydrogen
- Milk Cheese conversion


Economic Value
H2
Electrolysis
Physics
Thermal Value
Electricity
1kWh(3.6MJ)

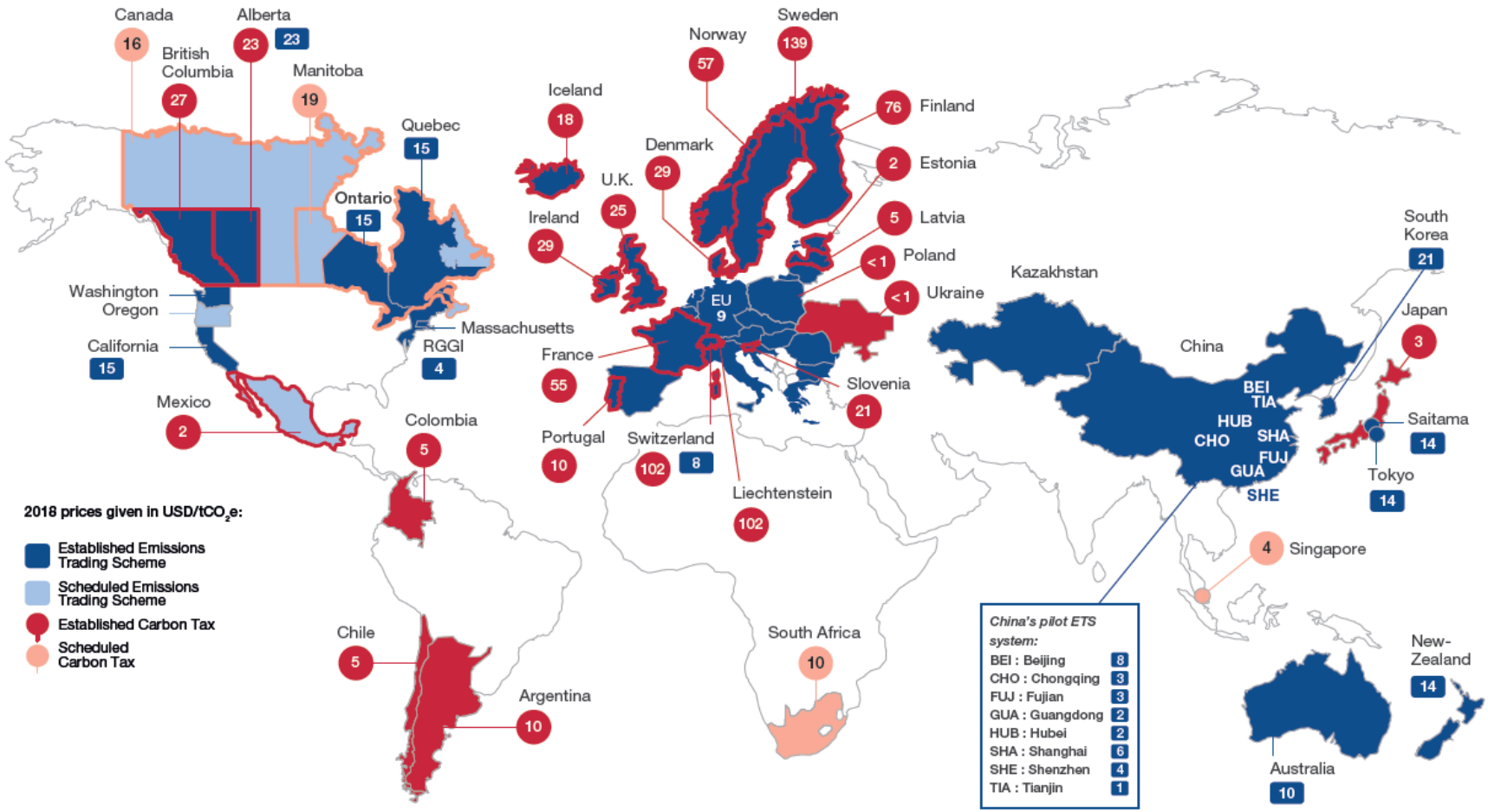
Fluctuated RE



TCO comparison OF Fuel for Transport with fuel Cell

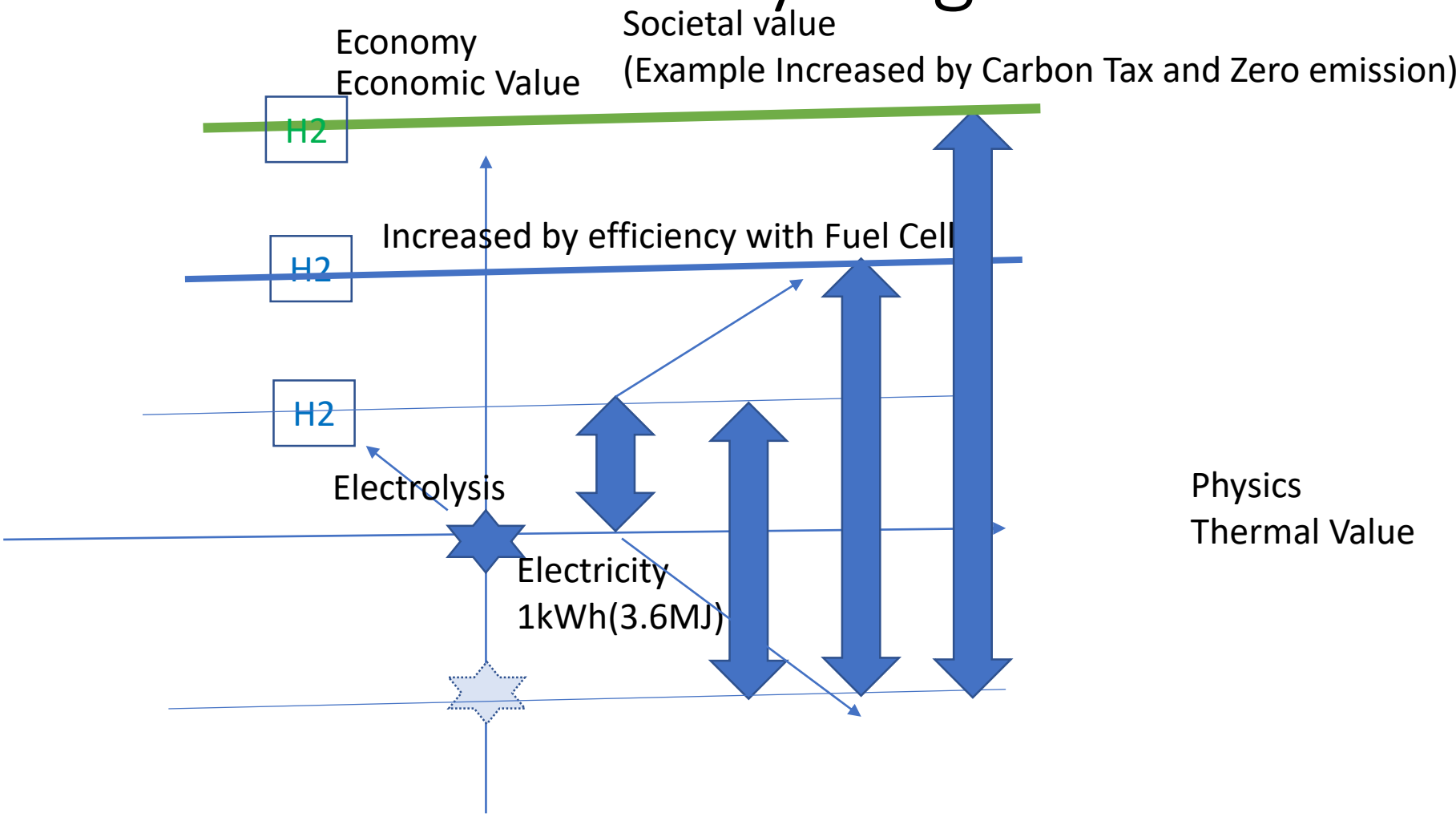


Map of explicit carbon prices around the world in 2018



Source: I4CE – Institute for Climate Economics with data from ICAP, World Bank, government officials and public information, April 2018.

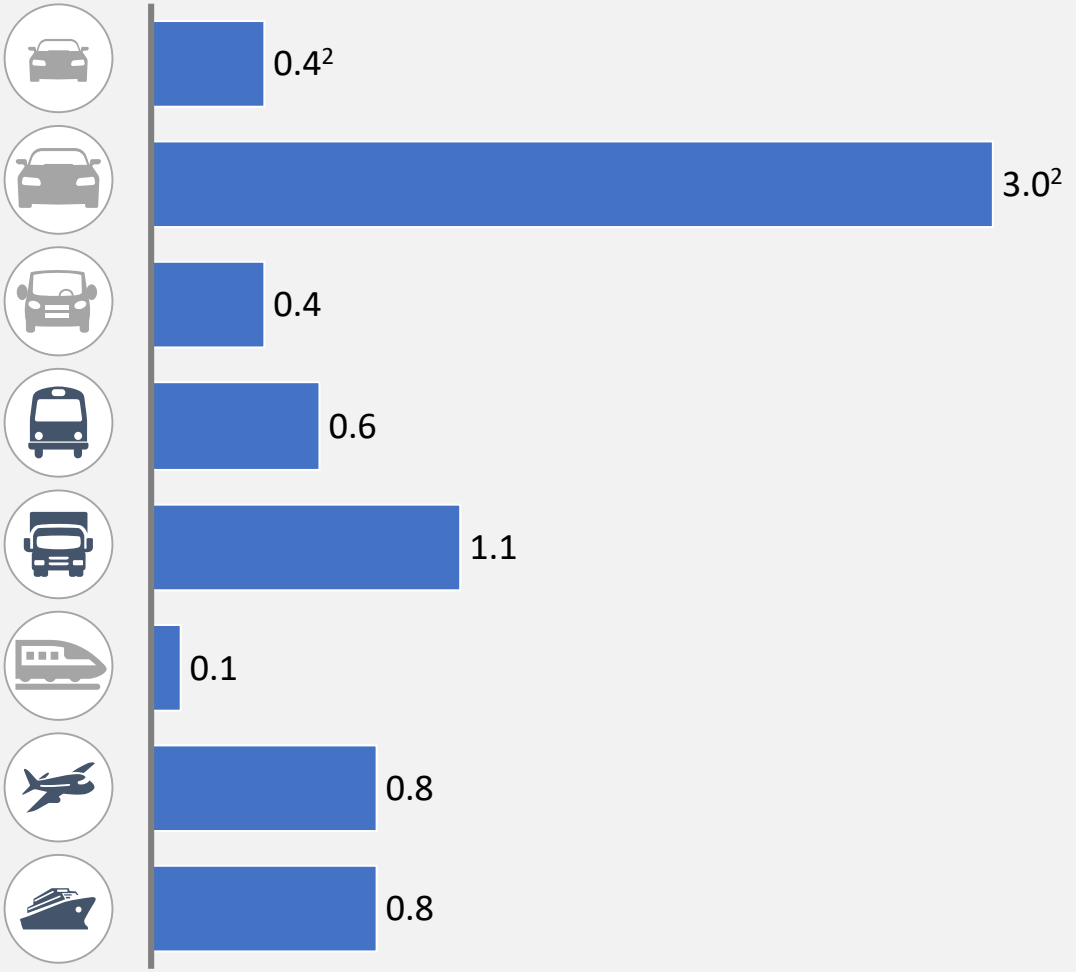
Societal Value of Hydrogen



BACKUP

4. Transport causes 20% of the total energy-related carbon emissions

GHG emissions in the transport sector, 2013, Gt CO_2



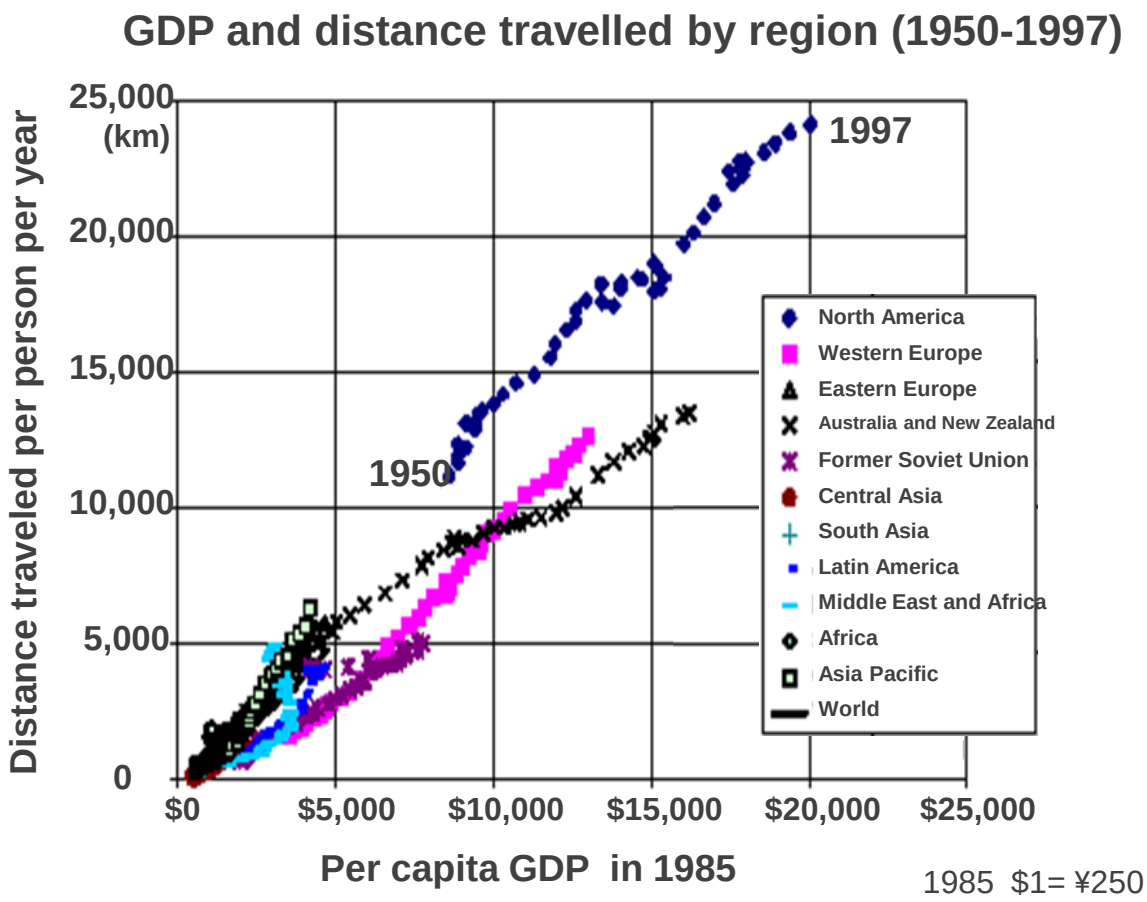
- **Transport sector emits 7.2 Gt of CO_2**
  - 20% of total energy-related CO_2 emissions[1])
- **Three complementary options for transport decarbonization exist:**
  - Battery electric vehicles (BEVs)
  - Fuel cell electric vehicles (FCEVs)
  - Bio- and (hydrogen-based) synthetic fuels

1 The global amount of energy-related CO2 emissions in 2013 was 34 Gt
2 Split in A- and B-segment LDV's (small cars) and C+-segment LDV's (medium-to-large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: ICCT, IPCC, IEA ETP 2016

Source: Hydrogen Council

Increase in distance traveled



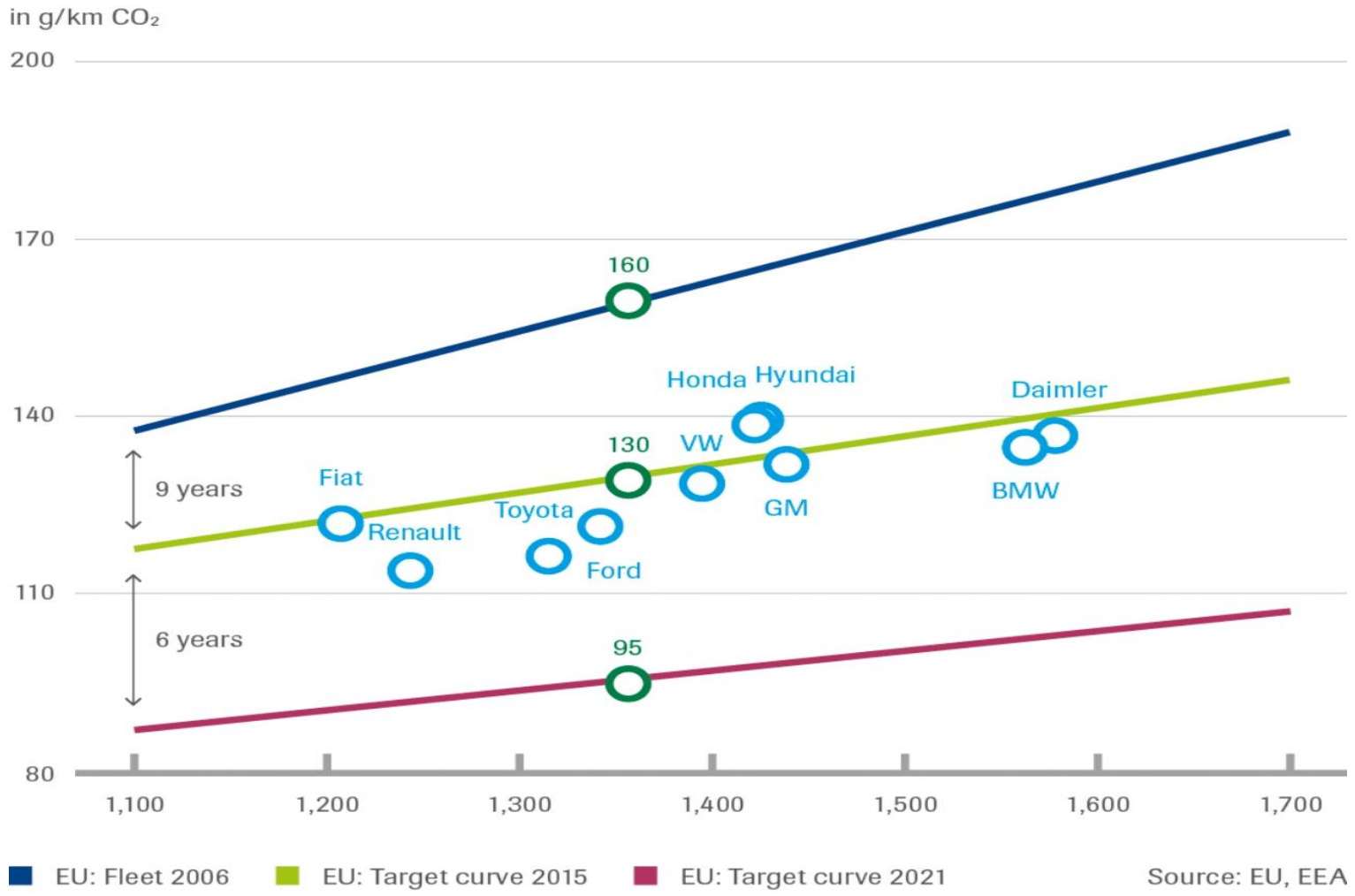
1985 $1= ¥250

Distance traveled has increased due to economic growth

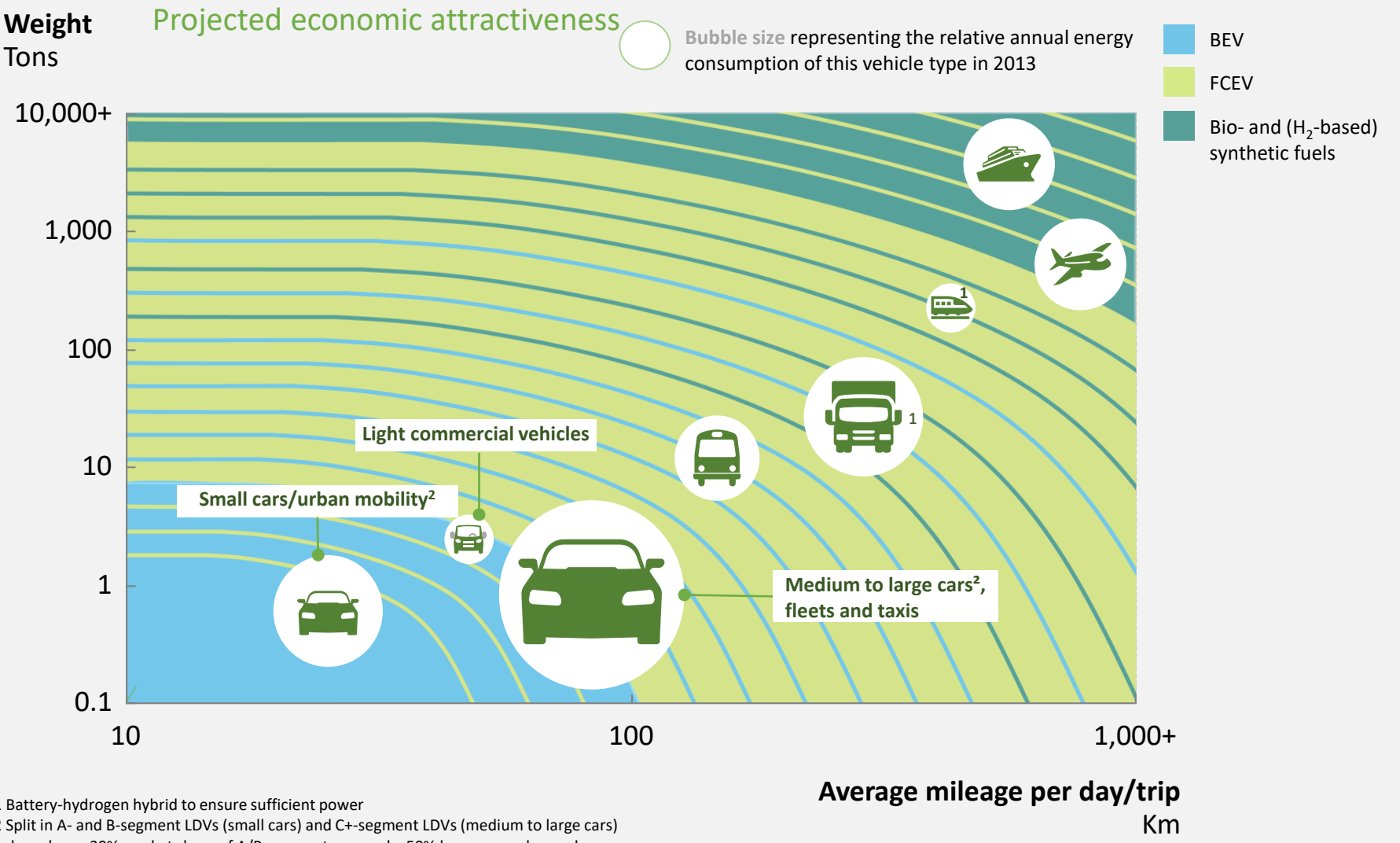
Source: WBCSD Mobility 2001

CO_2 target values: High requirements on the automotive industry

Average values of the vehicle fleet in kg



4. FCEVs will play an essential role in decarbonizing transport



1 Battery-hydrogen hybrid to ensure sufficient power
2 Split in A- and B-segment LDVs (small cars) and C+-segment LDVs (medium to large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: Toyota, Hyundai, Daimler

Source: Hydrogen Council

Hydrogen in Transport

HyFly Flying by hydrogen


Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center
Institute of Engineering Thermodynamics
H_2
ENERGIZING
TOYOTA
TOYOTA
AMATERSKO IZDELANO LETALO
DLR
Fuel Cell Hybrid – Powered by DLR


MIRAI
CONCEPT

Conclusion

Hydrogen will soon play an important role for the society to move decarbonized sustainable life.

- Holistic approach is necessary than sectorial approach
- Sharing the Long term Vision among stake holders and collaborate to achieve.
- Hydrogen Can Enhance Economy and Jobs.
- We still need to how the societal benefit converts into individuals' and Industries' benefit for acceleration

Trail Continues

Thank you

Transport/Mobility ongoing innovation and issues

- **Technologies**
  - **Electrification**
  - **Autonomous Driving**
  - **Safety collision less transport**
  - **Zero emission requirement Hydrogen and Battery**
- **Business**
  - **MAAS mobility as servis**
  - **Vehicle become commodity**
- **Energy/Fuel**
  - **Electrification**
  - **Zero emission Electricity / Hydrogen**
- **Mobility**
  - **High demand in non OECD**
  - **Serious Traffic jam in many countries Indonesia/ Thai**

Societal Value of Hydrogen