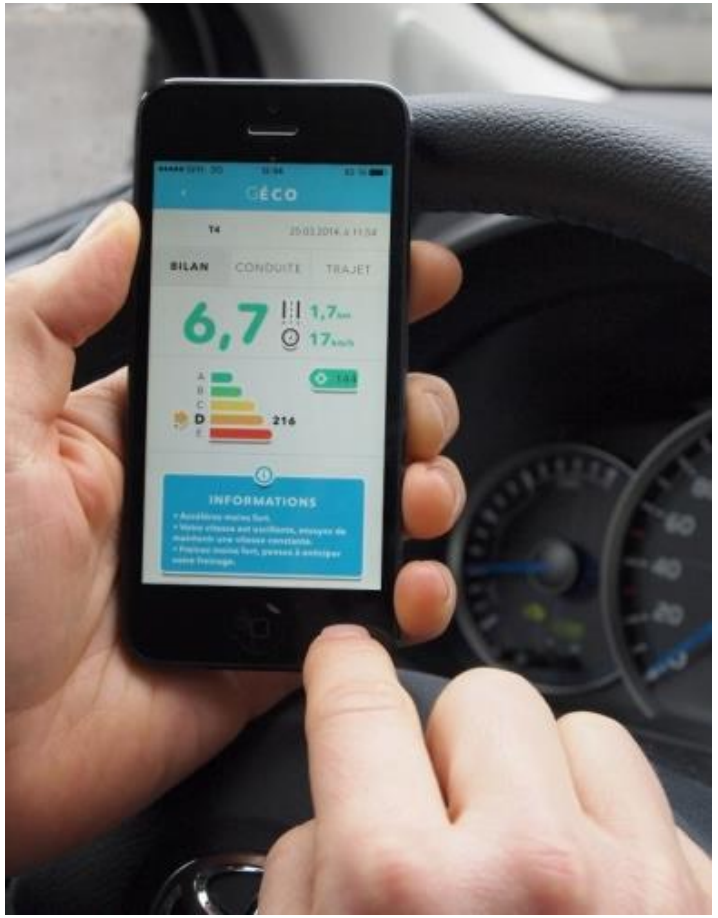


ECONOMIC ASPECTS OF THE HYDROGEN DEPLOYMENT

Franco-German Conference on Hydrogen, Paris, Oct. 22, 2018

François KALAYDJIAN

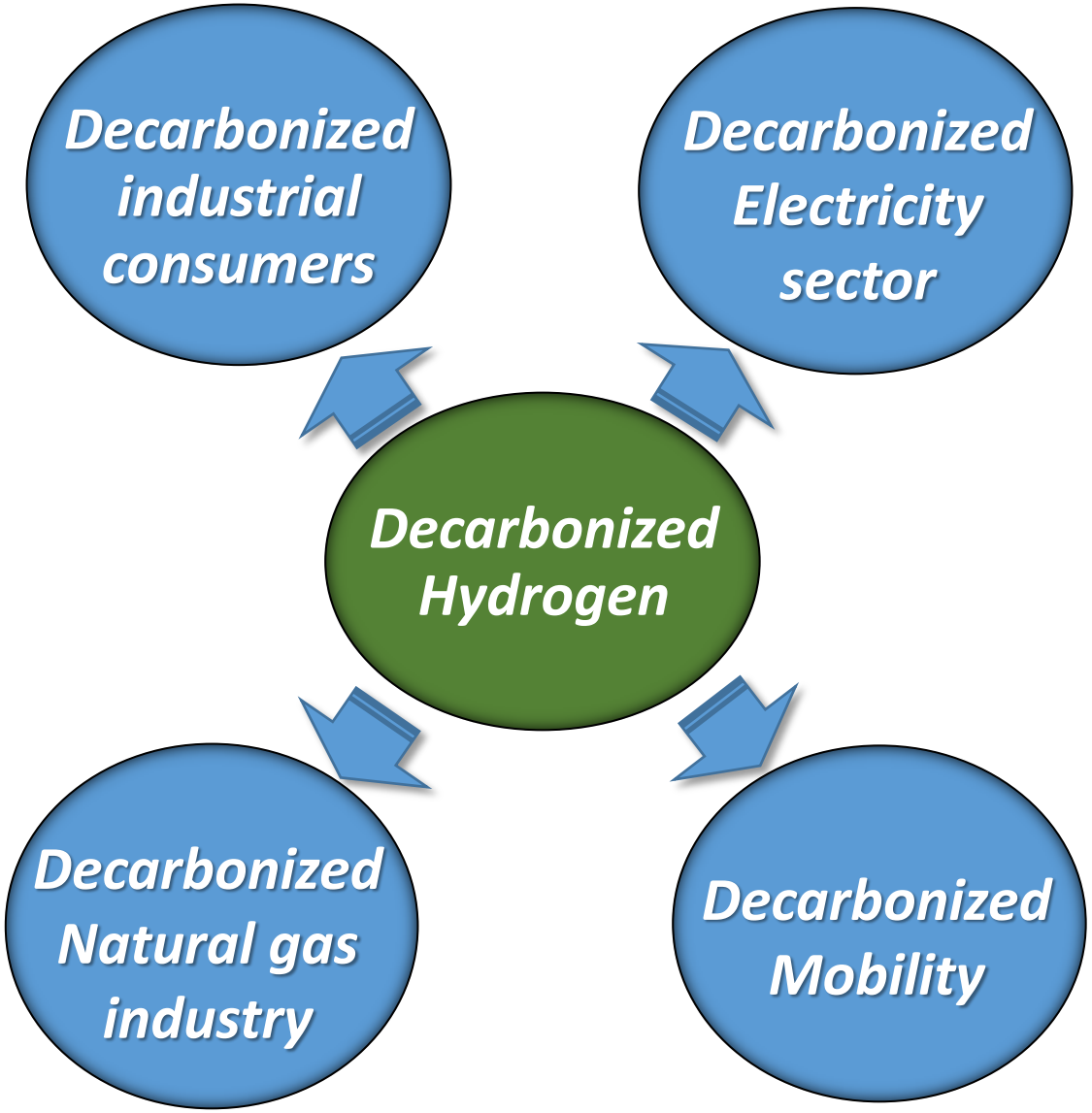
DIRECTOR, ECONOMICS & TECHNOLOGY INTELLIGENCE, IFP Energies nouvelles

IFP Energies nouvelles

AGENDA

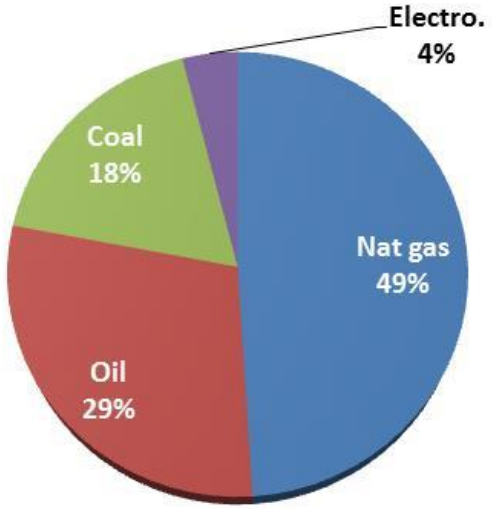
- Green Hydrogen : a contribution to a decarbonized energy mix
- The most economic option for valorizing a decarbonized hydrogen :
  → the direct sale to industries
- Reaching economic competitiveness in other applications (mobility, storage, …)
- Additional challenges to overcome for ensuring the deployment of a decarbonized hydrogen : production and transport

WHY HYDROGEN IN THE ENERGY TRANSITION?



HYDROGEN TODAY: FROM PRODUCTION TO INDUSTRIES

H2 world production
Main contribution : fossil energies

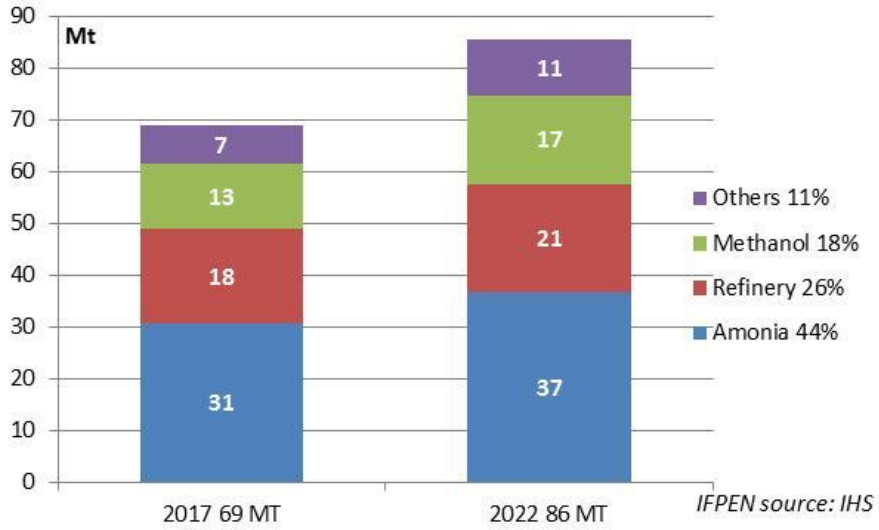


Source : HIS, 2018

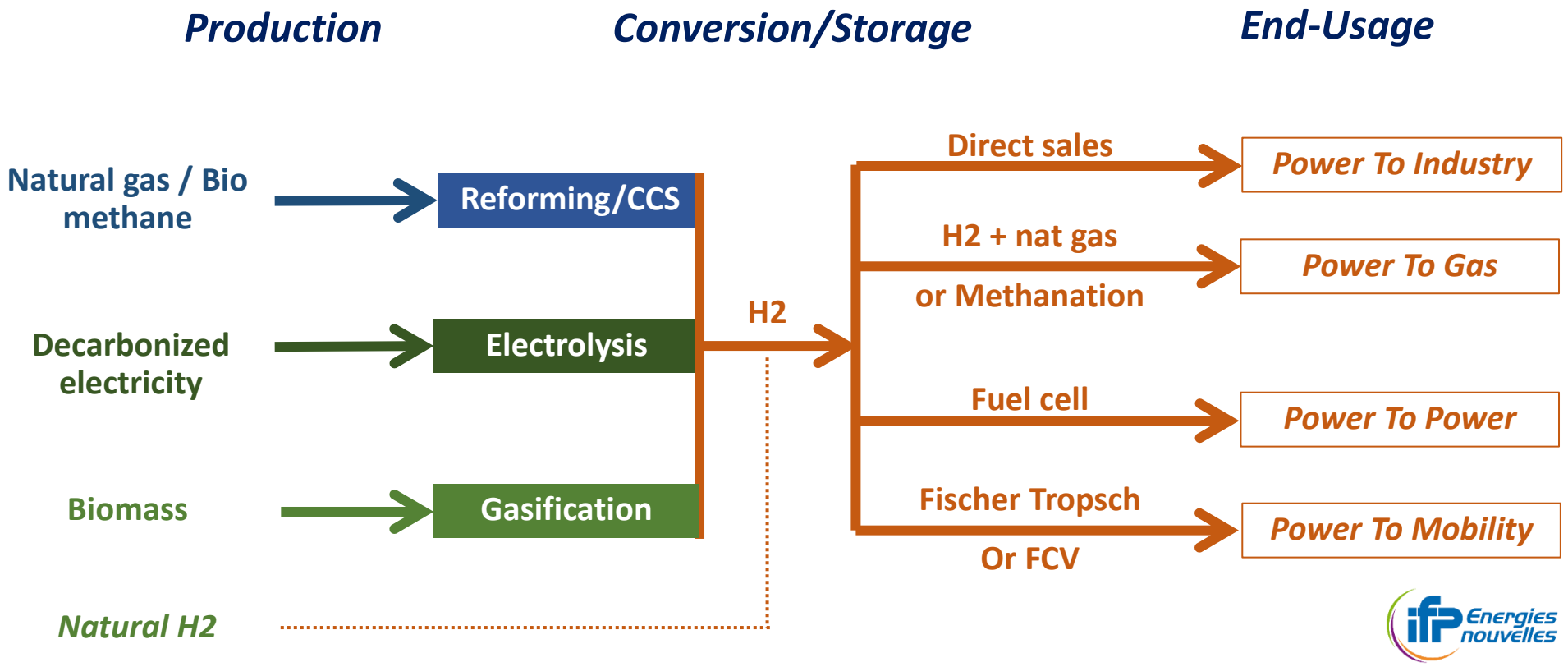
Existing Transportation Network

World: 4 500 km
Europe: 1 600 km
United States: 2 500 km

World consumption in 2017: ~70 Mt
e.g. 200 Mtep, 2% of primary energy demand

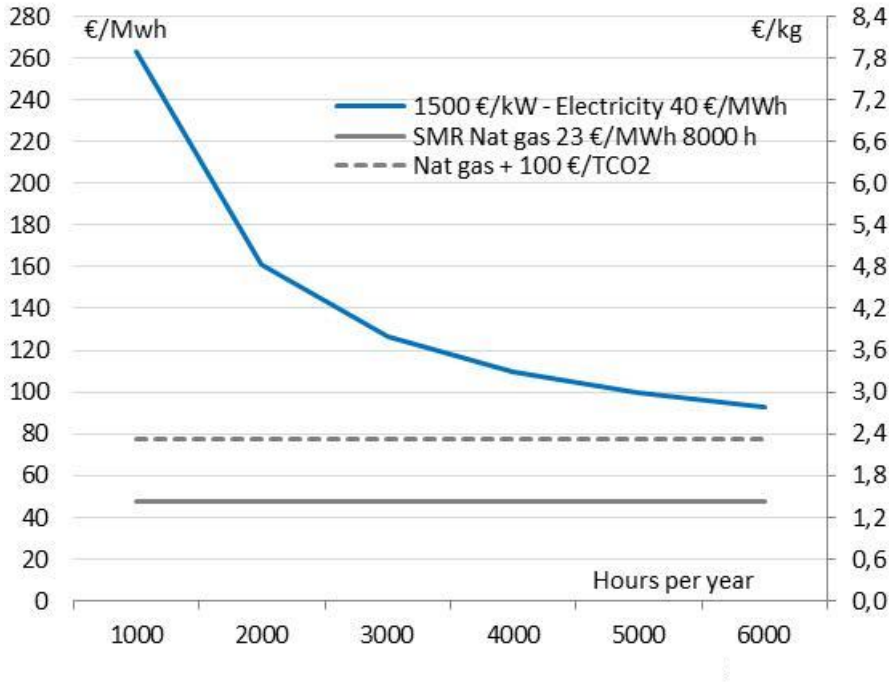


GLOBAL FUTURE HYDROGEN VALUE CHAIN



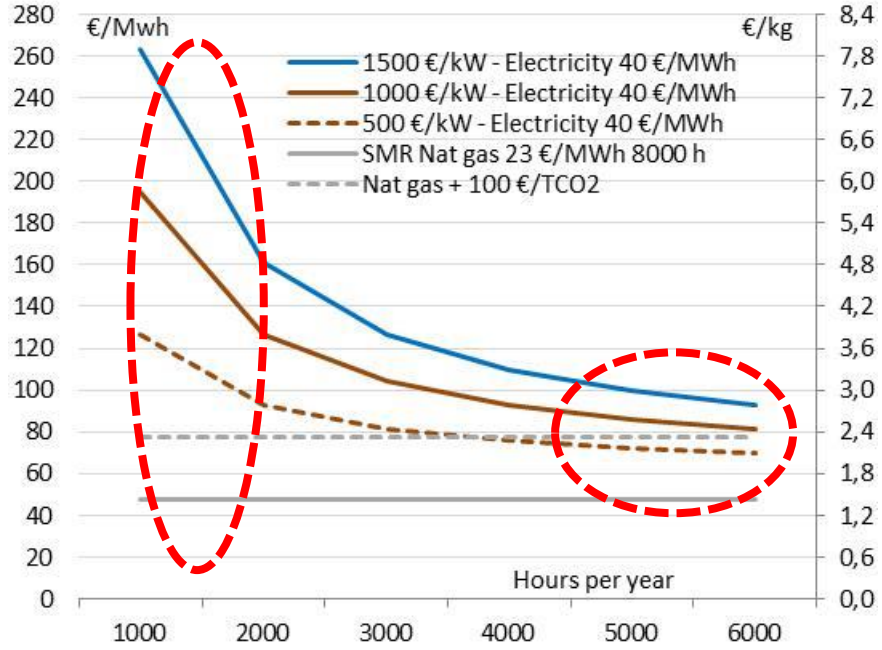
DIRECT SALES: THE PRESENT ECONOMIC CHALLENGES

- Cost comparison : electrolysis versus reforming
- Drivers
  - Annual availabilities
  - CO2 tax : above 100 €/tCO2



ELECTROLYSIS INVESTMENT – IMPACT ON H2 COST

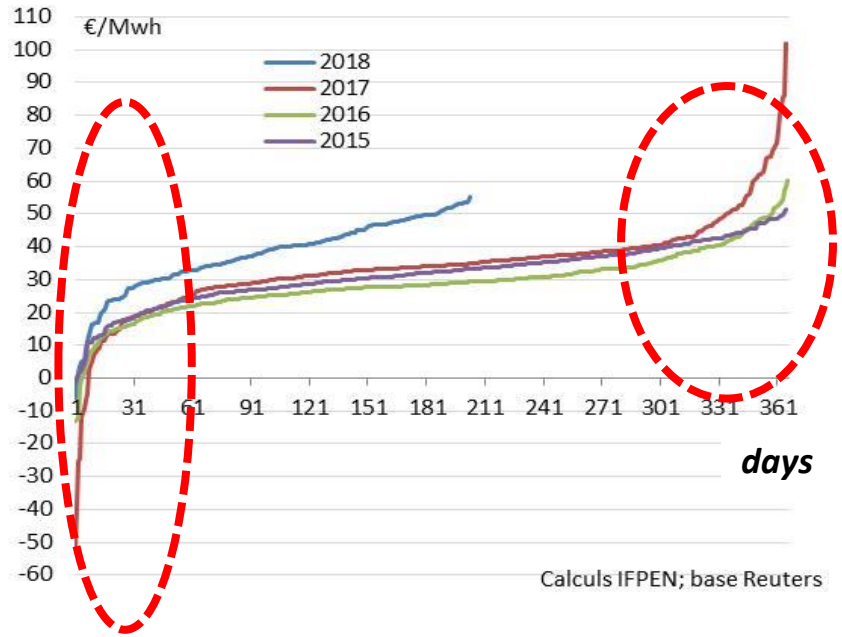
- **Assumptions**
  - Capex from 1500 to 500 €/kW
  - Electricity price : 40 €/MWh
- **H2 cost ex electrolysis**
  - 80 €/MWh min, ~ 2.4 €/kg
  - Equivalent to H2 ex SMR provided a CO2 tax of at least 100 €/t
- **Conclusions**
  - CAPEX important only for low availabilities
  - For high availability, within the assumptions made, the CO2 tax threshold can be reached in the coming years



Source IFPEN

ELECTRICITY: SPOT AND SALE PRICES

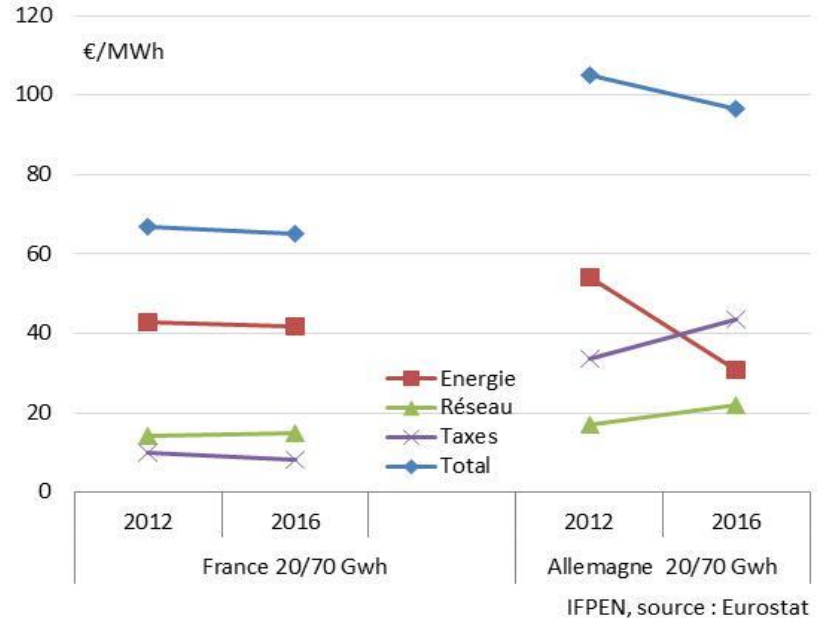
Daily spot prices (France)



30 to 40 €/MWh on average since 2015

Lower prices only for low availability

Electricity prices for a moderate consumption comprised between 20 and 70 GWh/yr

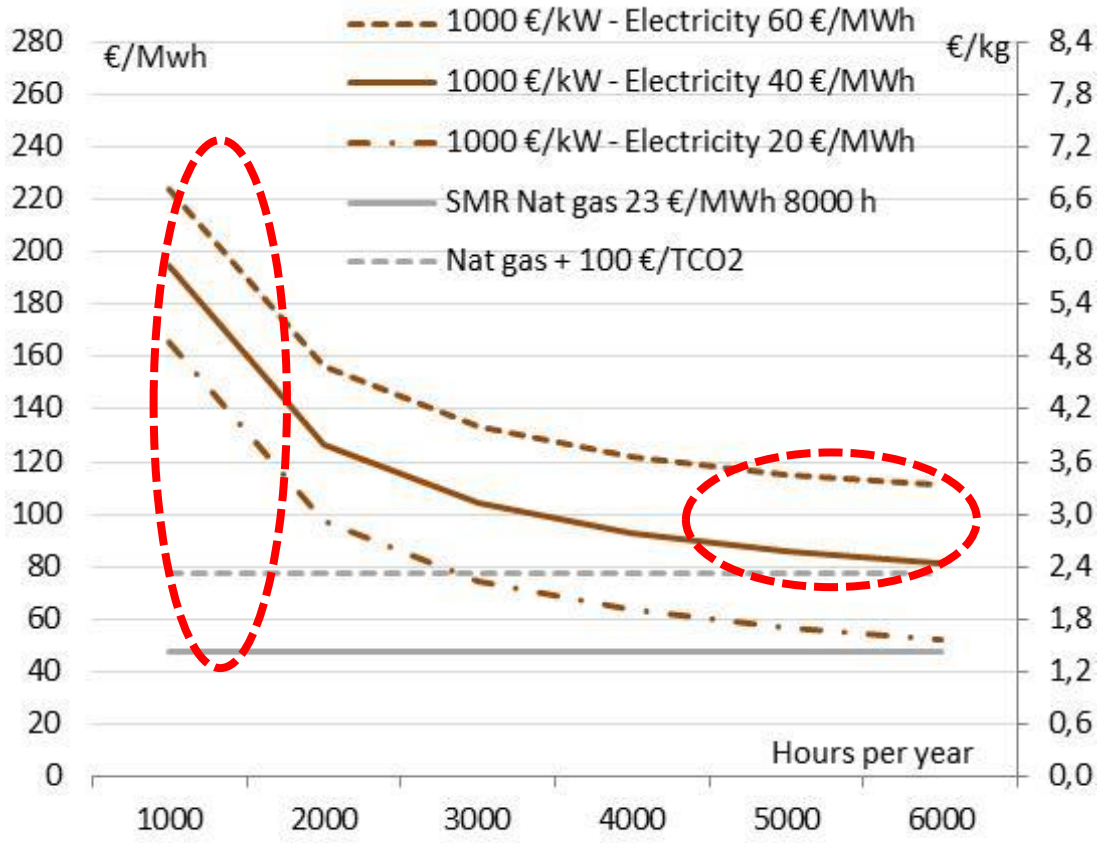


Higher sale prices for industrial

Taxes and network costs reduction for electrolysis ?

IMPACT OF ELECTRICITY PRICES ON H2 COSTS

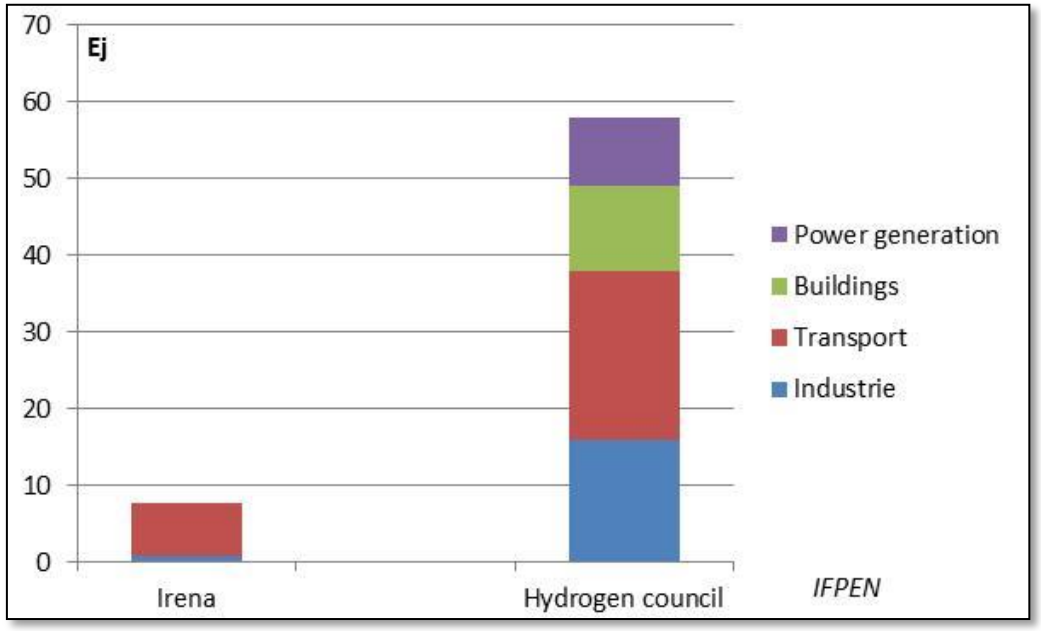
- **Assumptions**
  - Electricity prices : 20, 40 and 60 €/MWh
  - Capex: 1000 €/kW
- **Cost of H2 ex electrolysis**
  - 80 to 120 €/MWh
  - 2,4 to 3,6 €/kg
- **Conclusions**
  - CO2 taxation must exceed 100€/t for an electricity price above 60€/MWh



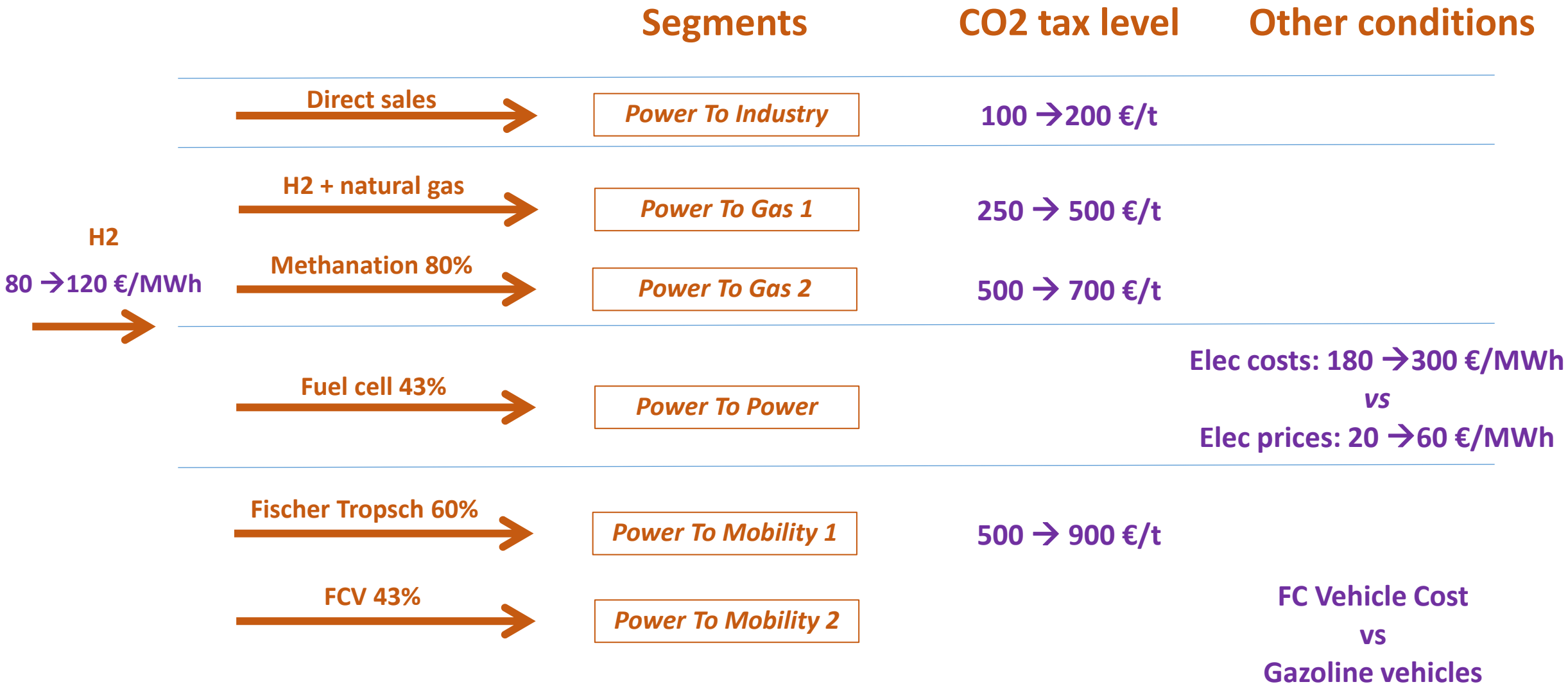
Source IFPEN

PROSPECTS 2050: OPPORTUNITIES BUT LARGE UNCERTAINTIES

- **H2 in the Energy mix**
  - H2 could contribute 18% to the final energy demand (Hydrogen Council)
- **H2 contribution to the Mobility sector**
  - IRENA : 8%
  - IEA : 1% in the SD scenario



GLOBAL COMPETITIVENESS BY SEGMENT



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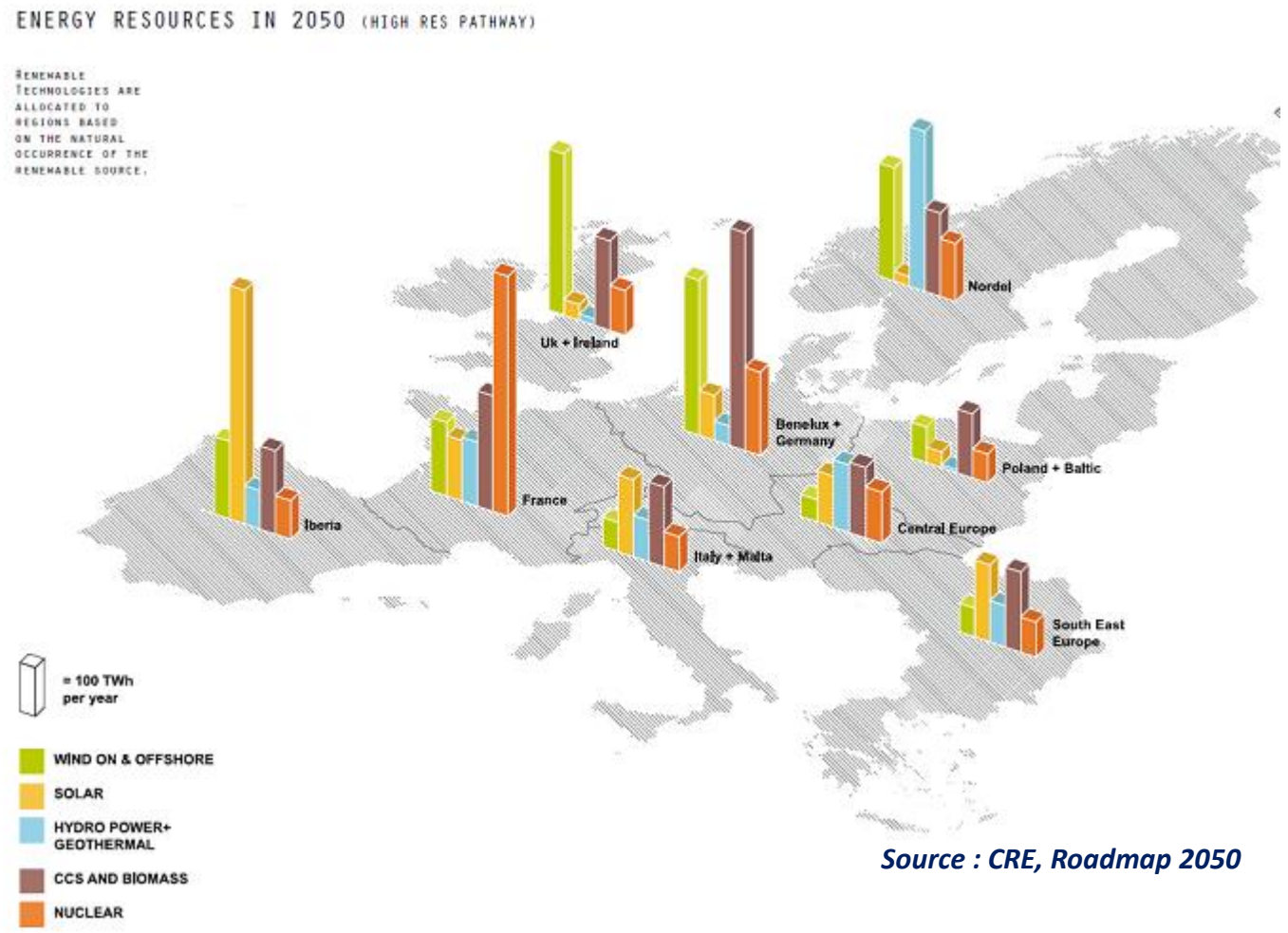
A NEW ELECTRICITY PRODUCTION MODEL IN 2050

- A mix of decarbonized sources
- Drivers :
  - Electricity cost
  - Availability



Source : CRE, Roadmap 2050

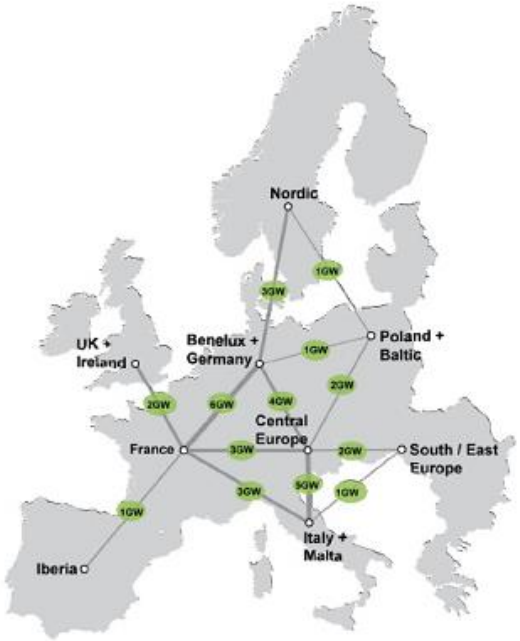
THE TRANSPORT AND PRODUCTION INFRASTRUCTURE

Hydrogen stations
1 Mn€/station

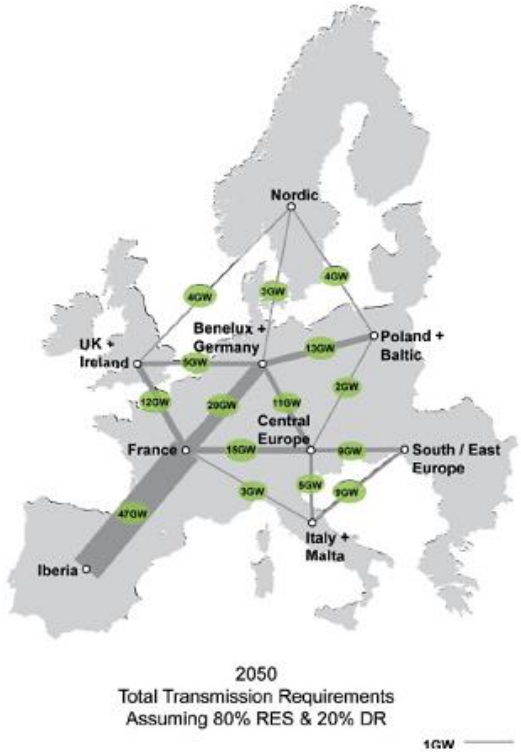
World: 260
100 in Japan
48 in Germany
9 in France

Source : IRENA, H2tools

Electricity network



2010
Existing Capacity

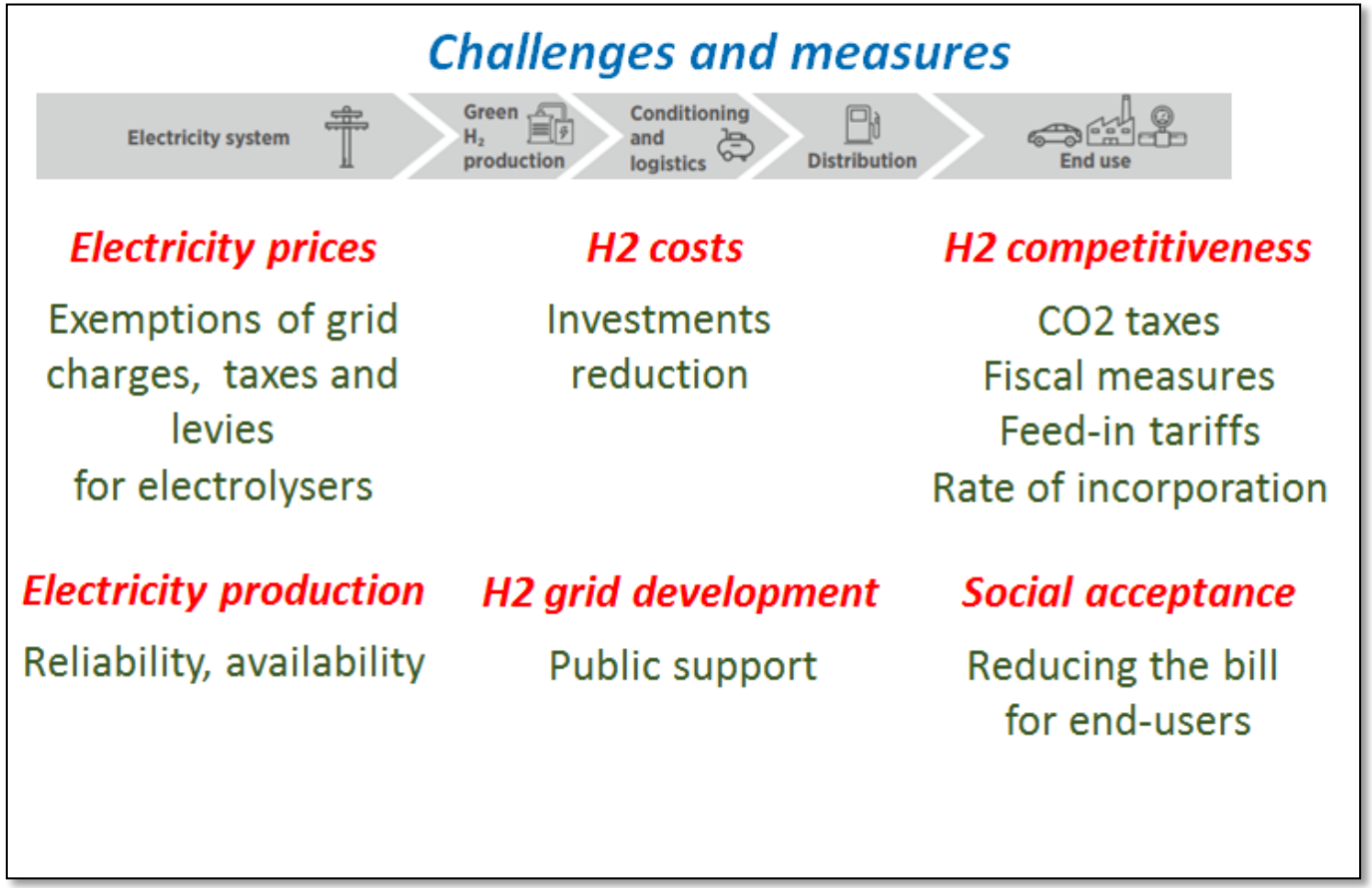


2050
Total Transmission Requirements
Assuming 80% RES & 20% DR

Source : CRE, Roadmap 2050

CONCLUSIONS

- Hydrogen, an opportunity for decarbonizing the energy mix
- Industrial sales : the most economic valorization option
- A competitiveness to secure
- A suitable framework to build



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