IEA Technology Roadmap on Hydrogen
Asia Workshop

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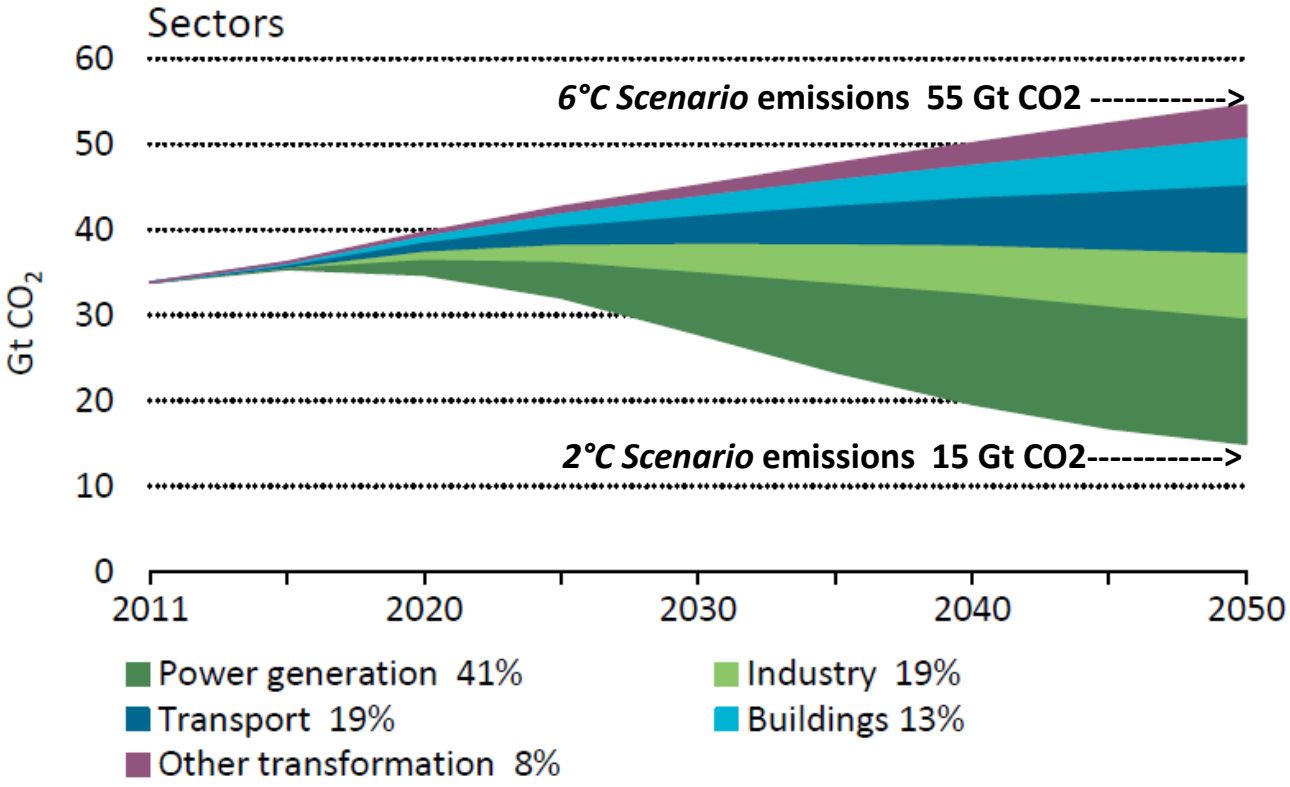
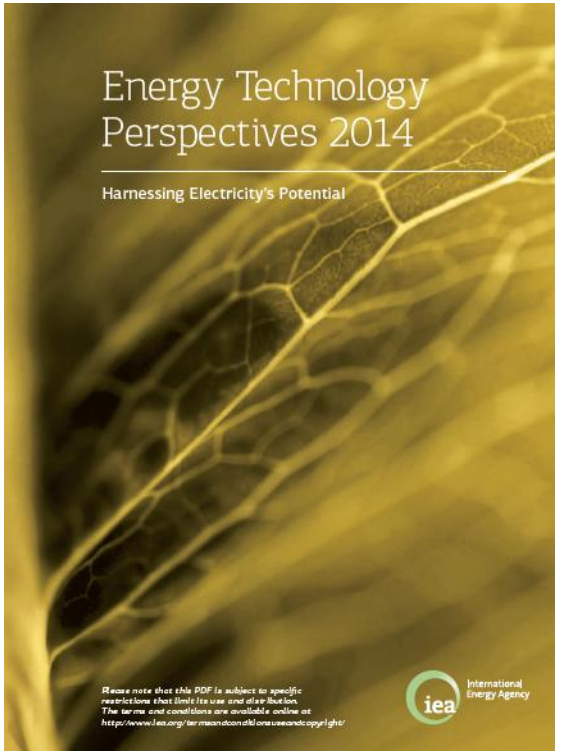
Climate change mitigation by sector





Source: Energy Technology Perspectives 2014

- Opportunities and challenges of hydrogen technologies in a 2°C world
- Actions to overcome key barriers to a widespread application of hydrogen technologies in the transport, industry and residential sector as well as on the energy supply side

Status of the Hydrogen Roadmap

- Kick-off meeting and Europe workshop July 9/10 2013 at IEA in Paris
- North America workshop January 28/29 2014 at HIA, Bethesda, Maryland
- Asia workshop June 26/27 2014 in Japan

- Carried out extensive literature review
- Reviewed data for transport input
- Sectoral analysis is underway
- Drafted preliminary milestones and key actions for discussion and review
- Drafting and review of the document Q3/4 2014
- Publication of the document Q1 2015

Outline of Hydrogen Roadmap

- Introduction
- Rationale for roadmap – H2 in the energy system
  - Transport
  - Stationary applications
  - Energy storage
  - Synergies between energy sectors
- Technology status today
- Vision for deployment to 2050 – Regional and global
- Technology development – Actions and milestones
- Policy, regulation, financing: Actions and milestones

Rationale hydrogen

- **Decarbonization of the energy system:**
  - **Transport sector: Increased demand for high energy density AND low carbon fuels creates demand for alternatives**
  - **Power sector: Increased demand for operational flexibility creates demand for energy storage and integrated systems**
  - **Stationary: Increased demand for highly efficient and integrated processes can foster the use of FC micro CHP systems in the residential sector and more efficient processes in the industry**

Key features of Hydrogen

- Potentially low carbon
- Very flexible energy carrier which can be generated from almost all PE to a suite of useful end-use energies
- Can store energy
  - At large scale over long time – Energy storage & variable renewable energy integration
  - At small capacities under restricted space and weight requirements - Transport
- Can be used as feedstock to reduce carbon footprint
- Hydrogen is used in large quantities already today

Key features of Hydrogen

- In the long term, hydrogen applications needs to built on:
  - The use of low carbon hydrogen
  - The need to store energy (either at larger quantities or in mobile applications)
  - The need to use hydrogen as a feedstock
- In the short term, existing infrastructure to generate and distribute hydrogen will have to play a great role to create hydrogen demand markets

Technology status today

- Discussion of key technology components
  - Electrolyzers, fuel cells and storage technology
- Discussion of demand side technologies
  - Fuel cell vehicles
  - Niche applications
    - Fork lifts, UPS
  - Japan specific discussion on micro fuel cell CHP
- Hydrogen distribution, transmission and retail infrastructure
  - Transmission technology – Gaseous and liquefied trucking, pipelines
  - Hydrogen refueling stations

Technology status today

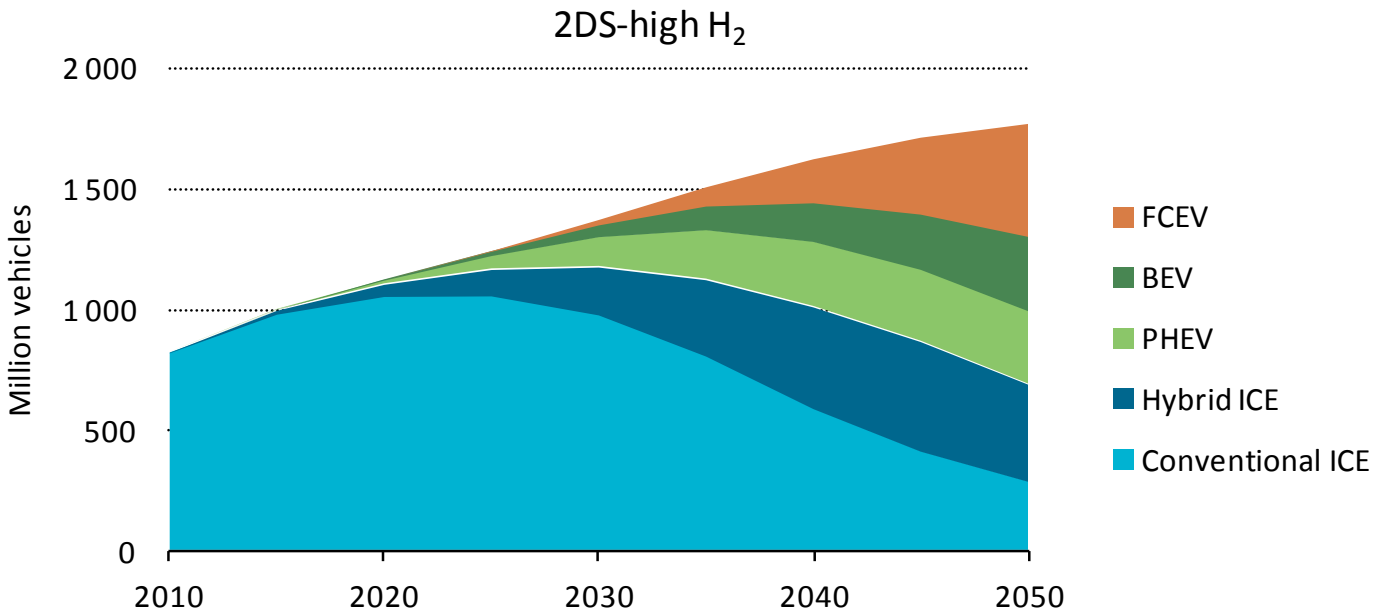
- Hydrogen based flexibility options for the power sector
  - Power – to – power
  - Power – to – gas (HENG)
  - Power – to – fuel
- Efficient steel making process
  - Blast furnace top-gas recovery with H2 separation and re-injection

Regional focus

- Detailed analysis will focus on the following regions
  - EU 4 – France, Germany, Italy, UK
  - USA
  - Japan
- Based on the regional results some global impacts will be quantified
  - E.g. CO_2 emission reduction potential of FCEVs in road transport
  - Emission reduction potential in the steel sector

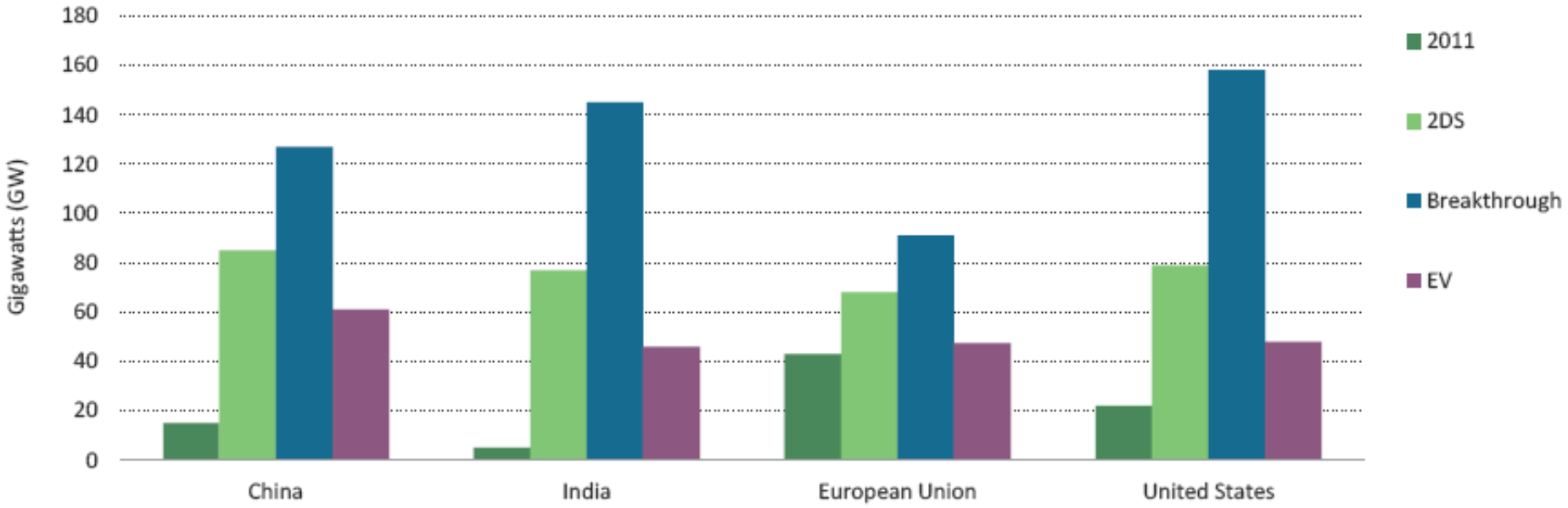
Vision – Transport

- **What if 25% of all PLDVs are FCEVs by 2050?**
  - **Vehicle sales and ramp-up rates**
  - **Discussion of fuel use and emission reduction potential**
  - **Costs and benefits**
  - **Focus: Infrastructure requirements and costs**



Vision – Hydrogen electricity storage

- **What if large scale hydrogen electricity storage can get competitive?**
  - **Estimation of storage potentials in high variable renewable energy integration scenario (ETP 2014 2DS)**
  - **What costs/efficiencies needs to be reached for H2 electricity storage technology to be competitive**



Technology scope: Steel industry

- Focus on how to improve the process rather than using hydrogen directly as an energy carrier
- Example: Blast furnace top gas recovery with H2 separation and re-injection
  - Process allows to reduce coke demand and reduce emissions
  - Assessments on cost of implementation
  - Assessments on necessary CO2 price

Next steps

- Finalizing analysis for energy storage and energy integration
- Collection of case studies for several H2 projects
  - Integrated energy storage and transportation project
  - Case study power-to-gas
  - Case study electrolyser and control power market
  - Case study fuel cell micro CHP (Japan)
- Further developing analysis for industry
- Drafting of milestones and key actions (additional WS?)
- Drafting of the document
- Circulation of the document for review Q4 2014
- Publishing the roadmap Q1 2015

International Energy Agency

Thanks!