

# US Hydrogen roadmap study

## HTAC Meeting update

PREREAD

December 2018

# Objectives today

- Alignment on **context**, **objectives** and **end products** of US Hydrogen Roadmap
- Alignment on **study approach** and **existing perspectives** on energy futures and hydrogen in the US as foundation for the roadmap
- Definition of **study setup**, **timeline** and **key milestones**
- Defining **next steps** including data request procedure, contract and logistics

Context, objectives and end products

Study approach and existing perspective  
on energy futures and hydrogen in the US

Study setup, timeline and key milestones

Next steps

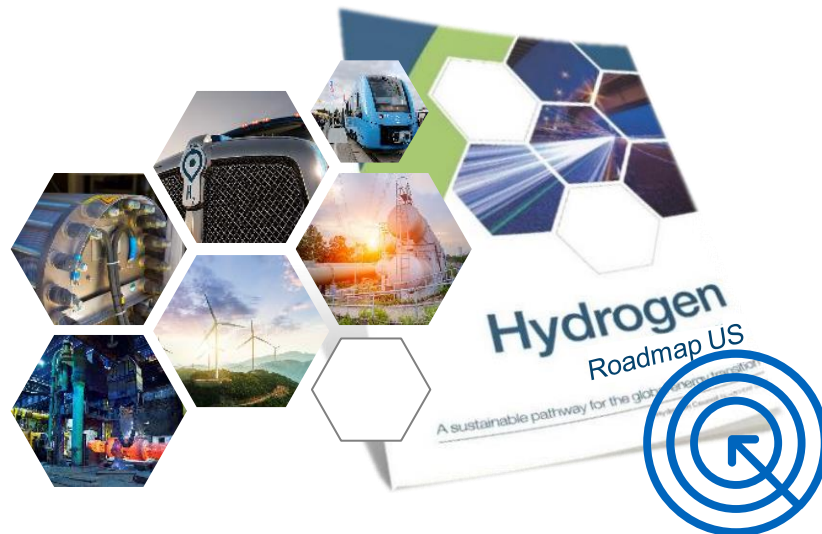
# Our understanding: The objective of the project is to develop a comprehensive hydrogen roadmap for the United States

## Context

- **Hydrogen and fuel cell technologies** have **reached technical maturity** in many application areas, but are facing introduction barriers, e.g., lack of infrastructure, transparency on specific needs and available technical solutions
- **The US is a leading player** in hydrogen technology through its large RD&D program led by the FCTO at the DoE, the leading role of California as a market for hydrogen mobility and the strength of US industry in hydrogen and fuel cells
- The next frontier for hydrogen is to demonstrate the **potential of hydrogen** for the US consumer, energy system and industry as a basis for building a deployment roadmap

## Objectives

- 1 **Set the ambition level:** Quantify the role played by the Hydrogen in the US energy system of 2050 in each sector and sub-sector
- 2 **Develop a roadmap:** Develop an adequate ramp-up including milestones for 2020, 2025 and 2030, taking into account inter-sectoral synergies
- 3 **Estimate the impact:** Quantify the environmental/climate, macro-economic and social benefits resulting from this roadmap



# We propose to structure our support around 3 work packages

## Work package

## Description

### 1 Ambition level for 2050

- Analyze US energy, economic and climate objectives at federal and state level, including a projection of the energy system in 2050
- Analyze existing work on hydrogen and energy futures in the US, and select areas for roadmap to build upon
- Jointly develop the aspiration for the Hydrogen roadmap, incl. areas to focus on in particular
- Jointly define the ambition level for hydrogen deployment in the US context (existing plans, energy prices etc.)

### 2 Roadmap

- Describe the status of the US hydrogen industry today
- Develop ramp-up curves for each sector until 2050, taking into account industrial constraints, cost trajectories and global spillover effects
- Estimate milestones for 2025 and 2030 for each sector

### 3 Impact

- Estimate the impact of the hydrogen roadmap on the US consumer and economy:
  - Macro-economic benefits, e.g., growth, trade balance, energy independence
  - Social benefits, e.g. jobs, competencies
  - Environmental benefits, e.g. pollution emissions decrease

# We base our approach for the US on lessons learned in other national roadmap



## Lessons learned in the European, French and Korean hydrogen roadmaps

### Differences in drivers and approaches

- **Drivers of hydrogen adoption and approaches to scaling up** the hydrogen economy differ strongly by country and have major implications on results
  - E.g., hydrogen imports and power generation in Korea due to constraints on renewables
  - E.g., fuel cell buses and vans in Europe due to pollution limits and driving bans in cities

### Differences in industry developments

- The **development of national industry across the value chain** differs strongly by country, impacting national capabilities and priorities
  - E.g., current focus on BEVs by French OEMs
  - E.g., existing national roadmap in Korea

### Industry coalition

- Members of the **industry coalition** differ strongly in their pre-existing knowledge and in their focus areas
  - E.g., companies investing in SMR vs. electrolysis

### External stakeholders

- Alignment and persuasion of **external stakeholders** are most successful when involved early in the process
  - E.g., city/state governments
  - E.g., SMEs

# Success factors for the US



## Lessons learned in the European, French and Korean hydrogen roadmaps

### Differences in drivers and approaches

- Jointly decide on **focus areas** and **aspired impact** for the roadmap
- Focus on **stringent arguments for hydrogen**, rather than a quantitative modelling of all segments in detail
- Consider **US specifics** from day 0 (e.g., lower importance of CO<sub>2</sub> abatement)

### Differences in industry developments

- Invest time upfront to **jointly build "foundation" for the study** before launching detailed analysis work; review existing US studies
- Consider **US-specifics** in approach

### Industry coalition

- Create **common understanding** of H<sub>2</sub> (supply, applications, technology...)
- Align objectives, scope and approach in **joint aspiration workshop in January**

### External stakeholders

- Identify and involve **outside stakeholders** in the process (e.g., invitations to government representatives, survey among SMEs)

We propose a 15-page visualization of the roadmap and a 40-page report outlining the key results of the study as end products

## Roadmap presentation



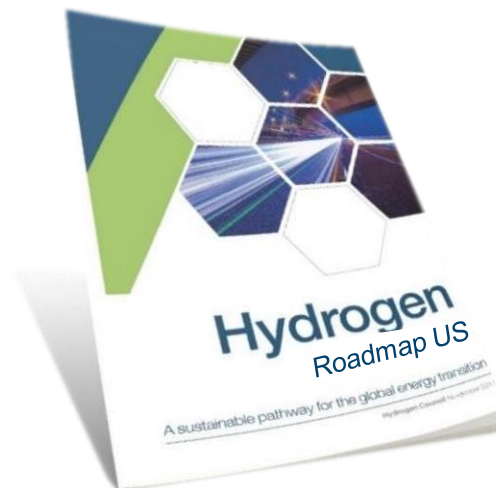
~15 slides visualization of the most important results of the roadmap:

- 2050 ambition
- Roadmap
- Impact

Targeted to be used for communication to key decision makers and to the public

In format similar to Hydrogen Council Roadmap

## Roadmap memo



~40 pages written report

Includes key results of study and selected visualizations

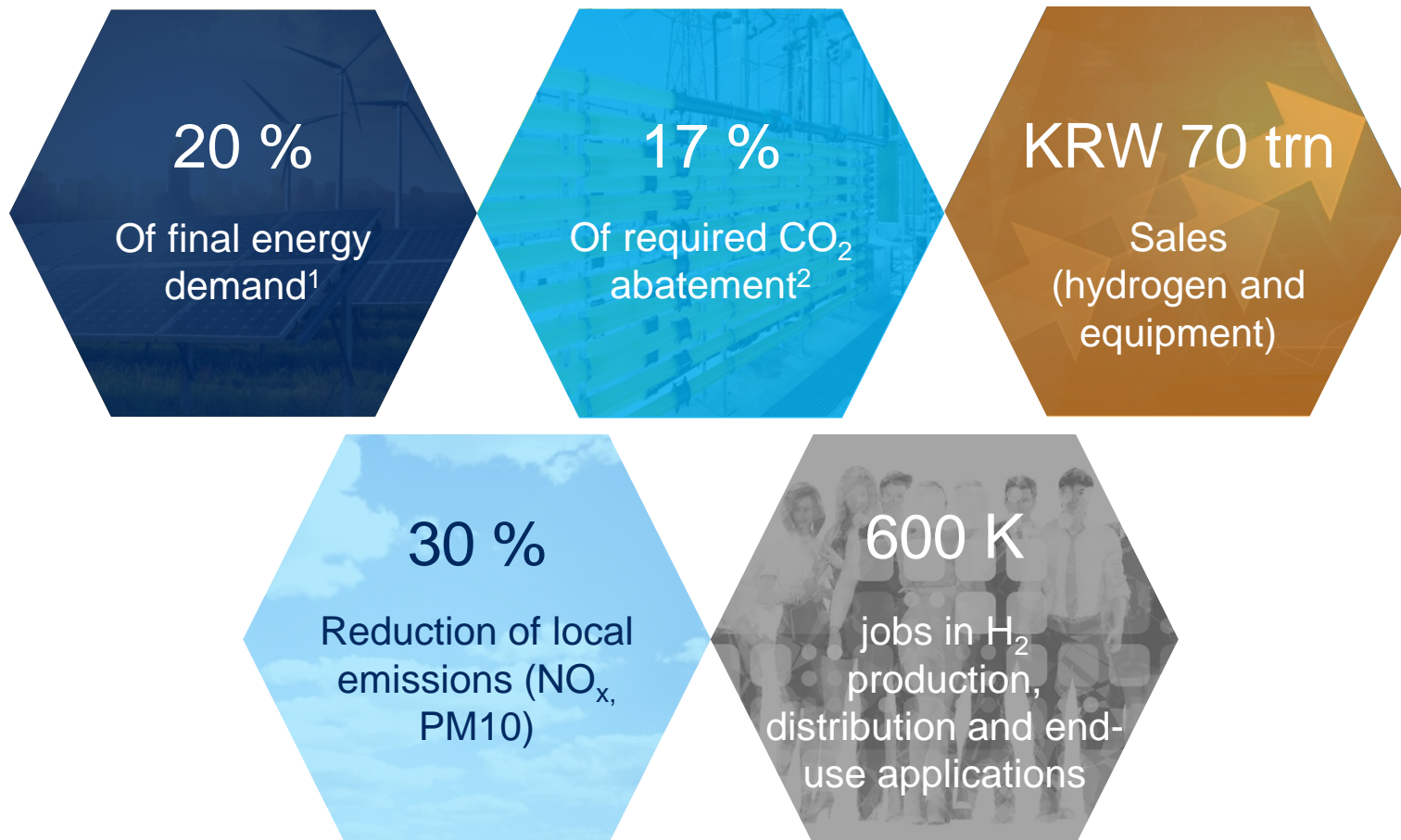
Targeted to be used for communication to policymakers and public





# Example output: Macro-economic impact and social benefits of the hydrogen vision for Korea

**2050 hydrogen vision**, in approximate annual figures



<sup>1</sup> Excluding feedstock hydrogen use    <sup>2</sup> Compared to the business-as-usual scenario



# Example output: Milestones in hydrogen scale-up in the hydrogen roadmap for Europe

**2030 and 2040 hydrogen milestones**, in approximate annual figures

	2030	2040	
<b>One in...</b>	12	5	... <b>light commercial vehicles sold</b> are FCEVs...
<b>...and one in...</b>	22	7	... <b>passenger vehicles sold</b> are FCEVs.
<b>There are...</b>	45 '000	450 '000	... <b>trucks and buses on the road...</b>
<b>...and...</b>	570	2,000	... <b>of diesel trains</b> replaced with hydrogen.
<b>There are...</b>	7 %	32 %	... <b>of natural gas (by volume) replaced by hydrogen</b>
<b>...equivalent to...</b>	30 TWh	120 TWh	
<b>...meaning...</b>	2 m	11 m	... <b>households</b> are heated.
<b>The deployment of...</b>	250 '000	2,560 '000	... <b>fuel cell CHPs</b> increases energy efficiency.
<b>There is...</b>	33 %	63 %	... <b>carbon-free hydrogen production</b> in all applications.

# Contents

Context, objectives and end products

Study approach and existing perspective  
on energy futures and hydrogen in the US

Study setup, timeline and key milestones

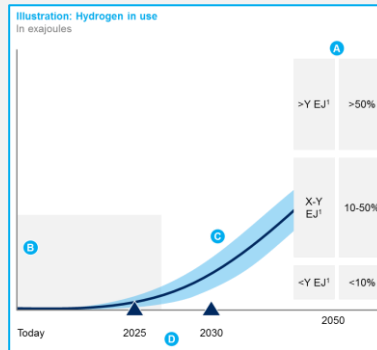
Next steps

# Overview of approach to building the Hydrogen Roadmap US

## Inputs per scenario

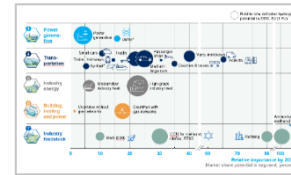
- **External/published data**
  - Energy system baseline and forecasts (energy demand, production mix, power prices)
  - US Hydrogen industry landscape
  - Environmental performance data and economic multipliers
- **Hydrogen Council data, validated by coalition members**
  - Hydrogen adoption rates
  - Cost data (capex and opex)

## Roadmap modelling

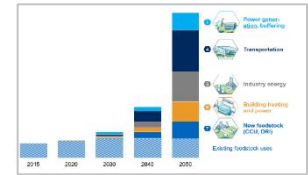


- A** Quantify the **vision for 2050**
- B** Define **starting point**
- C** Build **roadmap**
- D** Estimate **milestones**

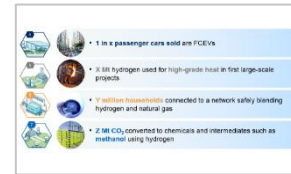
## Outputs/key analysis per scenario



Potential of hydrogen per application



Annual hydrogen demand



2030 and 2050 milestones of US hydrogen roadmap



Impact of hydrogen roadmap for the US

**For discussion:** What are the best existing studies and perspective on energy futures which we should use as foundation?

# Contents

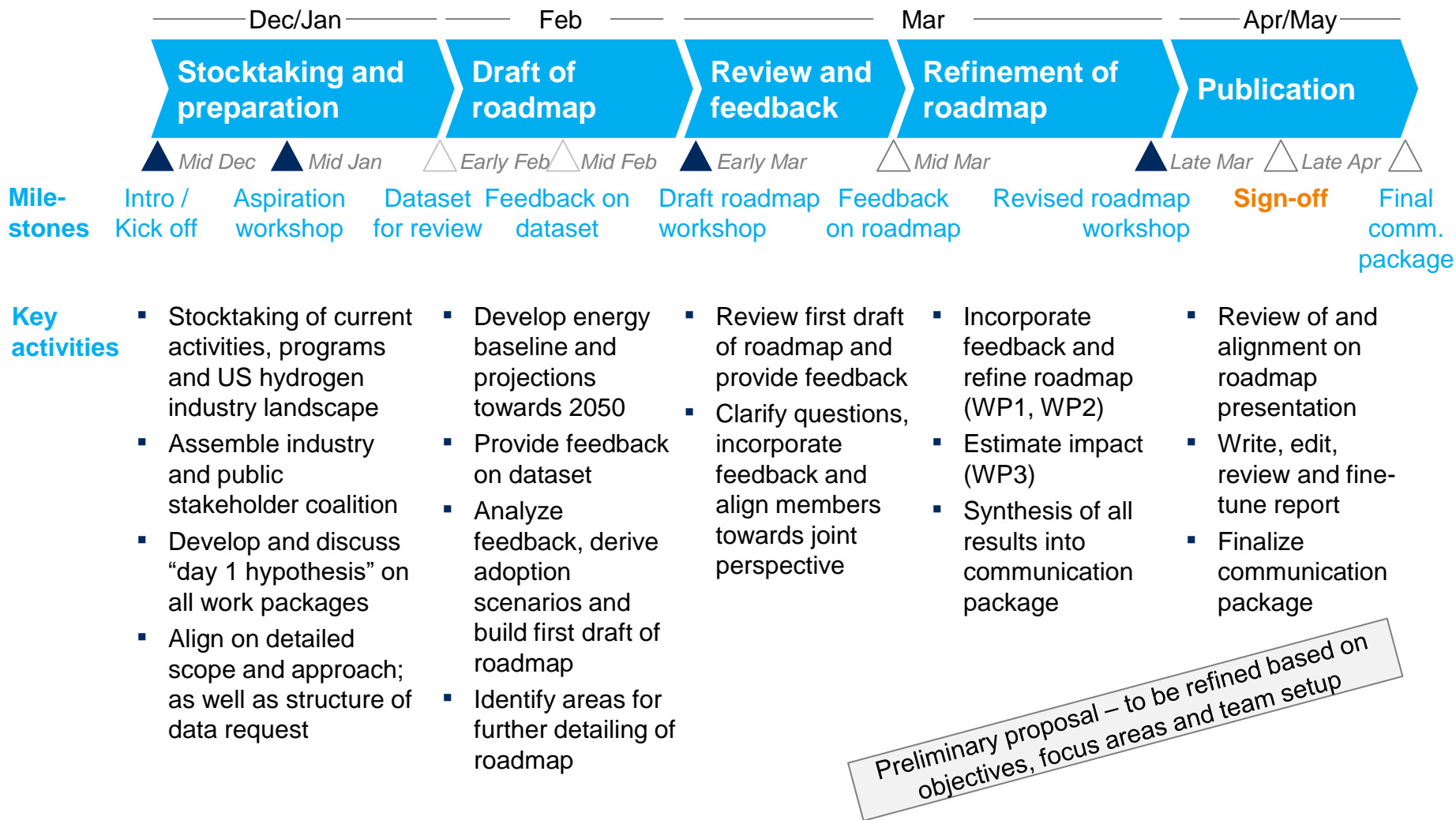
Context, objectives and end products

Study approach and existing perspective  
on energy futures and hydrogen in the US

Study setup, timeline and key milestones

Next steps

# We propose an approach of 4 months to develop the roadmap in a coalition with industry and public stakeholders



1 Prices quoted in EUR, free of all duties, taxes and other charges, including VAT. Prices quoted are fixed amounts including all charges (including travel and subsistence).

# Roles and responsibilities of Steering group and Study group

Groups	Members	Roles	Meeting schedule	Contribution
<b>Steering Group</b>	<ul style="list-style-type: none"> <li>Small set of companies</li> </ul>	<ul style="list-style-type: none"> <li>Actively <b>steering the project with high level of commitment</b> across the project</li> </ul>	<ul style="list-style-type: none"> <li>Weekly calls</li> </ul>	<ul style="list-style-type: none"> <li>Very <b>active involvement</b> in the project and <b>weekly project calls</b>; <b>providing input</b> data; <b>reviewing workshop material</b> and taking prepared <b>leading rolls in workshops</b>; reviewing interim project results; <b>providing feedback and guidance</b></li> </ul>
<b>Study Group</b>	<ul style="list-style-type: none"> <li>All coalition members</li> </ul>	<ul style="list-style-type: none"> <li><b>Guiding the project with expertise</b>, focusing on core areas of each partner</li> </ul>	<ul style="list-style-type: none"> <li>Workshops</li> </ul>	<ul style="list-style-type: none"> <li><b>Providing input</b> data; <b>providing feedback</b> on the outputs, <b>active participation in workshops</b> and participate in discussions</li> </ul>

Context, objectives and end products

Study approach and existing perspective  
on energy futures and hydrogen in the US

Study setup, timeline and key milestones

Next steps



# Open questions and next steps

Questions	<b>Coalition members</b>	<ul style="list-style-type: none"> <li>Participating companies?</li> <li>Who will represent the companies? <i>We would recommend each member to nominate 1-2 project contacts for participation in meetings and as experts during data alignment phase</i></li> </ul>
	<b>Logistics</b>	<ul style="list-style-type: none"> <li>Where should meetings take place?</li> <li>Who will participate in key meetings and who will send out invitations?</li> </ul>
	<b>Kickoff meeting</b>	<ul style="list-style-type: none"> <li>When should the aspiration workshop with the full group take place?</li> <li>What is the preferred location?</li> </ul>
	<b>Contract</b>	<ul style="list-style-type: none"> <li>Contract closure and signing between FCHEA and McKinsey</li> <li>Signing of NDA with coalition members and FCHEA</li> </ul>
Next steps	<b>Before kickoff</b>	<ul style="list-style-type: none"> <li>Assemble participating companies and their contacts</li> <li>Send out invitations for all workshops</li> <li>Gather/share existing perspectives on energy and hydrogen in the US</li> <li>Prepare kickoff meeting</li> </ul>
	<b>After kickoff</b>	<ul style="list-style-type: none"> <li>Circulate assumption data set / survey for validation and input from US companies</li> </ul>