Determination of the Hydrogen Specification for Transportation Applications

ROLE OF THE USFCC

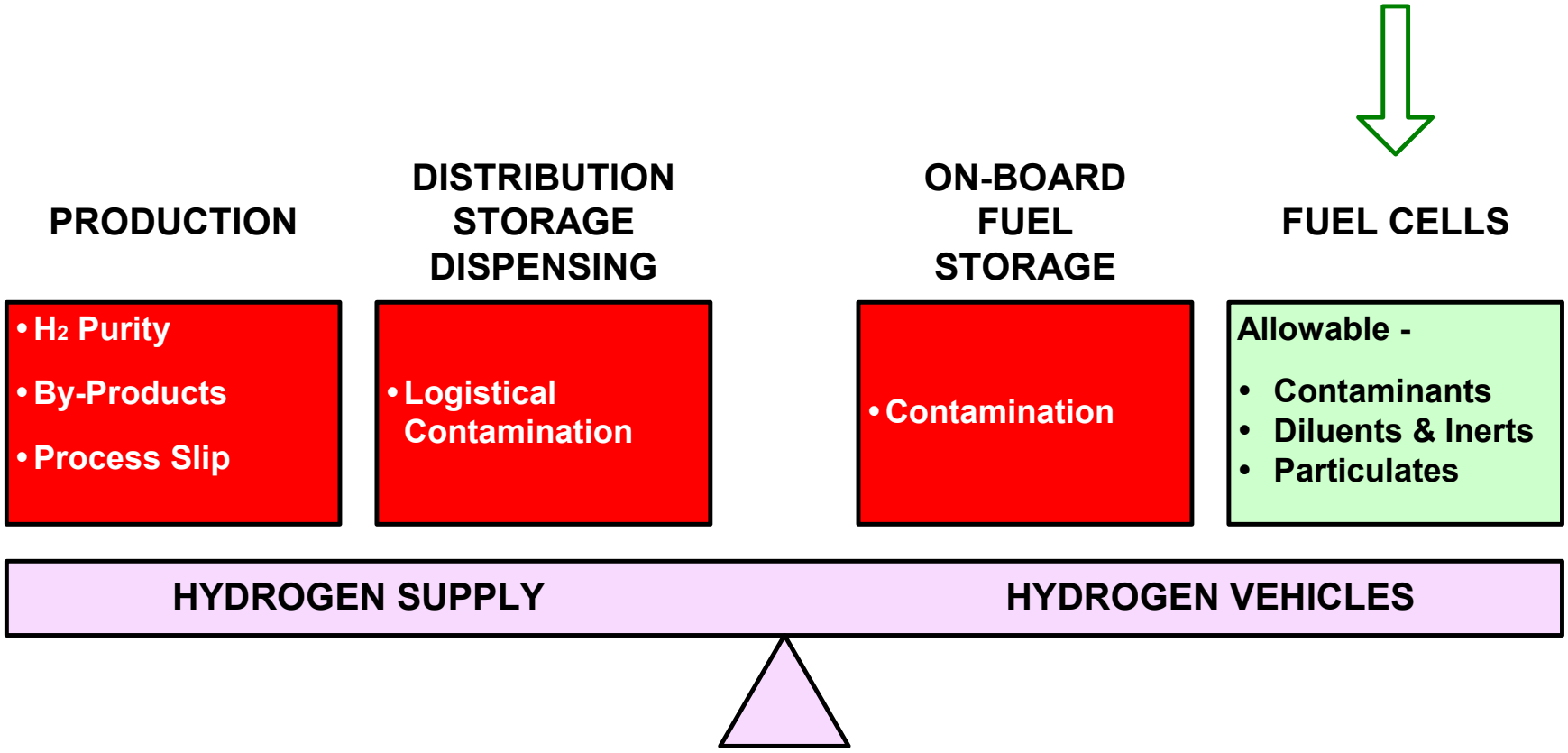
TRANSPORTATION WORKING GROUP

USFCC-0004
2004 April 23

Elements of Consideration when Specifying Hydrogen Purity

Finding a Cost Effective Solution for Transportation

Focus of USFCC Contribution is impact on fuel cell stack

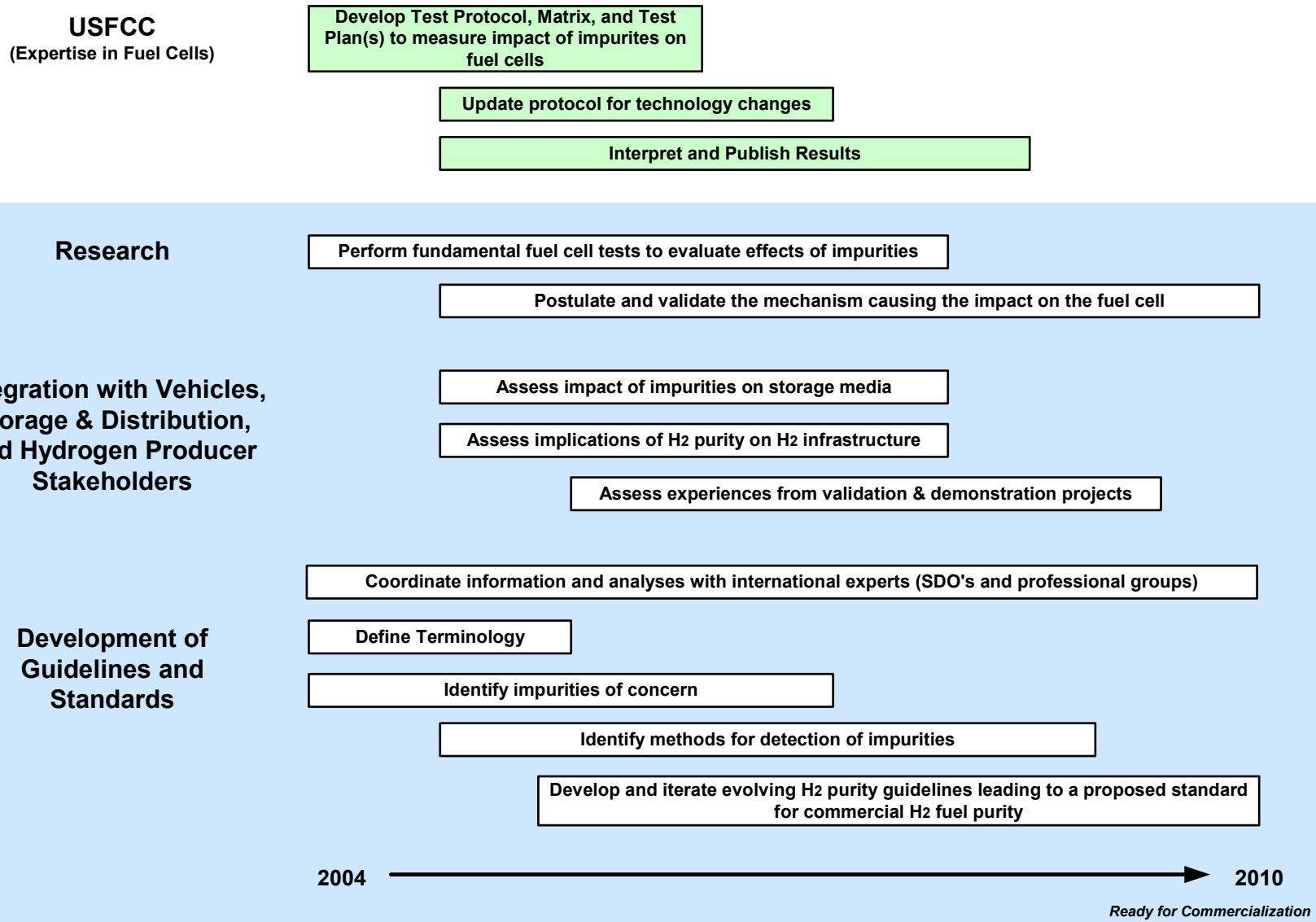


Need to strike a balance between supply costs and vehicle requirements.

Categories of Hydrogen Impurities & Stakeholders

Types of Impurities of Interest		Stakeholders
• **Catalytic / Cell Contaminants**	***Permanent***	**Fuel Cell Manufacturers**
• **Diluents and inerts**	***Recoverable* Non-condensable***	**System Integrators**
•**Particles**	***Condensable Solid***	**Vehicle Manufacturers**

Key Activities from Perspective of USFCC



USFCC Role and Responsibilities

- **Propose Fundamental Cell Testing (target 12/04)**
  - **Recommend single cell test design and operating parameters (see Table 1)**
  - **Identify contaminants (see Table 2)**
  - **Recommend test protocol**
  - **Recommend test matrix**
- **Evaluate Test Information (FY04 – FY08)**
  - **Develop understanding of mechanisms causing adverse fuel cell impact**
  - **Recommend reconciliation of diverse test results**
  - **Identify contaminants with impacts resulting from long-term and short-term exposure**
- **Revise Test Protocol for Evolving Learnings & New Materials(FY04-FY08)**
- **Publish findings on a regular basis (annual)**

Example of Expected Elements in Proposed Single Cell Test Design and Operating Parameters

Parameter	Minimum or Typical Value	Maximum
Operating Time • Continuous operation • Life		Up to 10 hours 5000 Hours
Current Density	250 ma/cm2 (average)	1000 ma/cm2 (peak)
Catalyst Loading • Anode • Cathode	*Based on 0.2g/kW:* 0.0 mg/cm2 .0 mg/cm2	0.3 mg/cm2 (Pt or Pt-Ru) 0.3 mg/cm2 (Pt)
External Hyd e Utilization	Over 99%	Over 99% desired
Temperature	Subfreezing	80 degC
Pressure	Atmospheric	2.5 Atmospheres (gauge)
Humidifier	As specified by manufacturer	

Example of Target Contaminants

		Impurity Effect		Impurity Property		
Impurity	Comments	Inert	Contaminant	Condensable	Non-condensable	Particulate
Water (H_2O)	Set by tank mfrs and VMs	X		X		
Argon (Ar)		X			X	
Helium (He)		X			X	
Nitrogen (N_2)		X			X	
Ammonia (NH_3)			X		X	
Carbon Dioxide (CO_2)		X	X		X	
Carbon Monoxide (CO)			X		X	
Formic Acid (HCOOCH)			X		X	
Formaldehyde (HCHO)			X		X	
Hydrocarbons:						
1) Methane (CH4)		X			X	
2) Non-methane alkanes	C2H6, C3H8, etc.		X		X	
3) Olefines			X		X	
4) Aromatics			X		X	
Sulfur (Total all compounds)	H2S, COS, and SO2(?)		X		X	
K+	In water from electrolyzers		X			
Na+	In water from NaBH4		X			
Chromium (Cr)	Set by tank mfrs and VMs		X			X
Iron (Fe)	Set by tank mfrs and VMs		X			X
Mercury	From Chlor-Alkali		X	?	?	
Nickel (Ni)	Set by tank mfrs and VMs		X			X
Oxygen	Set by tank mfrs and VMs		X			X

Example of Inputs for Contaminant Testing

- **Example Elements of a Recommended Test Protocol**
  - **Overview of test program**
  - **Quality control criteria for repeatable and reproducible results**
    - **Definition of components, measurement accuracy and calibration**
  - **Reporting of information**
    - **Type of information, Accuracy of information**

- **Example Elements of a Recommended Test Matrix**
  - **Grouping of probable impurities by common families**
  - **Variations to be tested**
    - **Contaminant amount**
      - **Contaminant levels, exposure duration, flow rates**
    - **Pressure; total and partial**
    - **Temperature**
  - **Interactions between contaminants**

- **Example Elements of a Recommended Test Plan**
  - **Overview of test plan**
  - **Requirements**
    - **Apparatus, measurements, tolerances**
  - **Baseline test conditions and operating parameters**
  - **Variations in physical exposure conditions (temperature, pressure, relative humidity)**
  - **General test procedures and diagnostics**

SUMMARY

Role of USFCC is to Apply Expertise to:

- **Recommending a robust test protocol for use by diverse organizations to evaluate impacts of hydrogen impurities on fuel cells**
- **Evaluating test information to assess the mechanism by which hydrogen impurities impact fuel cells**
- **Publishing findings and Advising Standards Development Organizations**

US Fuel Cell Council

1625 K Street, NW, Suite 725
Washington, DC 20006
202-293-5500
www.usfcc.com