U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

HFTO Subprogram Perspectives

Eric L. Miller

Dave Peterson

Ned Stetson

Dimitrios Papageorgopoulos

Jesse Adams

Neha Rustagi

HFTO – Program Managers

Moderated by Eric L. Miller, HFTO Chief Scientist

2024 Annual Merit Review and Peer Evaluation Meeting

May 6, 2024– Arlington, VA

The Hydrogen and Fuel Cell Technologies Office (HFTO)

Mission

Research, development and demonstration (RD&D) of hydrogen and fuel cell technologies to advance:

- **Clean Energy and Emissions Reduction Across Sectors**
- **Job Creation and a Sustainable and Equitable Energy Future**

HFTO Subprograms

Hydrogen Technologies

- Hydrogen Production
- Hydrogen Infrastructure

Fuel Cell Technologies

- Materials & Components
- Systems

Systems Development & Integration

- Transportation
- Chemical & Industrial Processes
- Energy Storage & Power Generation

Systems Analysis

Safety, Codes and Standards

Cross-cutting/Enabling: manufacturing, supply chain, workforce, regional clean H_2 networks

Enabling

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H2@Scale U.S. Department of Energy

Hot Off the Press- HFTO's Updated MYPP!

Strategic Priorities		Near-Term 2025	Mid-Term 2030	Longer Term
Clean Hydrogen Production	• **Affordable, efficient, and durable electrolyzers** for **GW-scale** operations • **Innovative approaches to clean H_2 production**, beyond electrolysis			
Hydrogen Infrastructure Technologies	• Affordable and reliable components and systems for **H_2 transport and dispensing in heavy-duty applications** • **Advanced H_2 liquefaction and carrier distribution concepts** • **Low-cost vessels** for high-pressure gaseous and cryogenic liquid H_2 storage • **Innovative H_2 storage materials** for high-density, low-pressure storage			
Fuel Cell Technologies	• **Efficient, durable, and cost-competitive fuel cells** for heavy-duty applications • **Advanced materials and components** for next-generation fuel cell technologies in diverse applications			
Systems Development and Integration	• **Transportation and H_2 fueling** demonstrations • **Chemical and industrial processes** integrating H_2 technologies, focusing on decarbonization • **Energy storage and power generation** including integrated and resilient hybrid energy systems			
Systems Analysis	• **Tools, modeling, and analysis** to prioritize RD&D and inform early-market deployments • **Regional analysis** to support energy transition planning and assess impacts • **Integrated analysis** to inform supply chain expansion and sustainable market growth			
Safety, Codes and Standards	• **H_2 component technologies safety**, including materials compatibility and environmental modeling, emphasizing near-term dispensing applications • **Safety, codes, and standards** with additional emphasis on bulk storage and large-scale applications of hydrogen			
Crosscutting/ Enabling	Collaboration within HFTO and across offices and other federal agencies to enable low-cost, high-volume domestic manufacturing and recycling, a robust domestic supply chain, good-paying U.S. jobs, regional clean hydrogen networks, and energy and environmental justice and diversity, equity, inclusion, and accessibility.			

www.energy.gov/eere/fuelcells/mypp

Hydrogen Production Subprogram Overview

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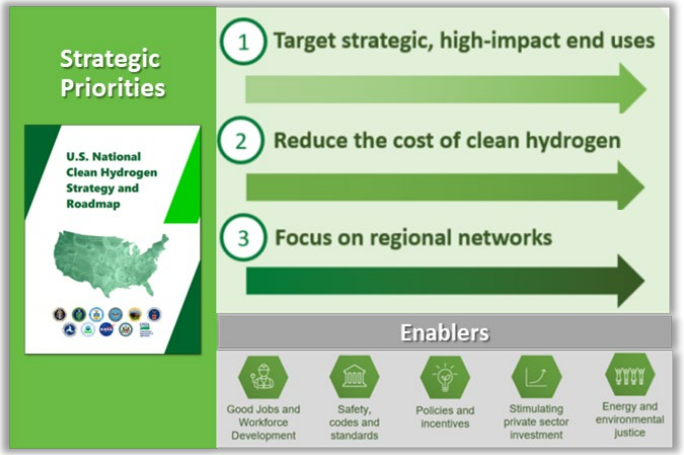
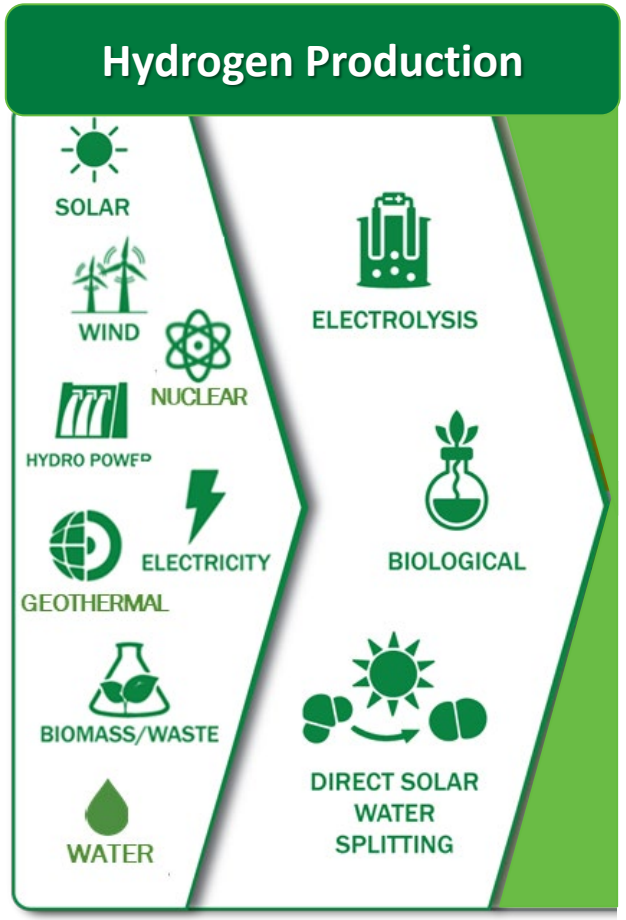
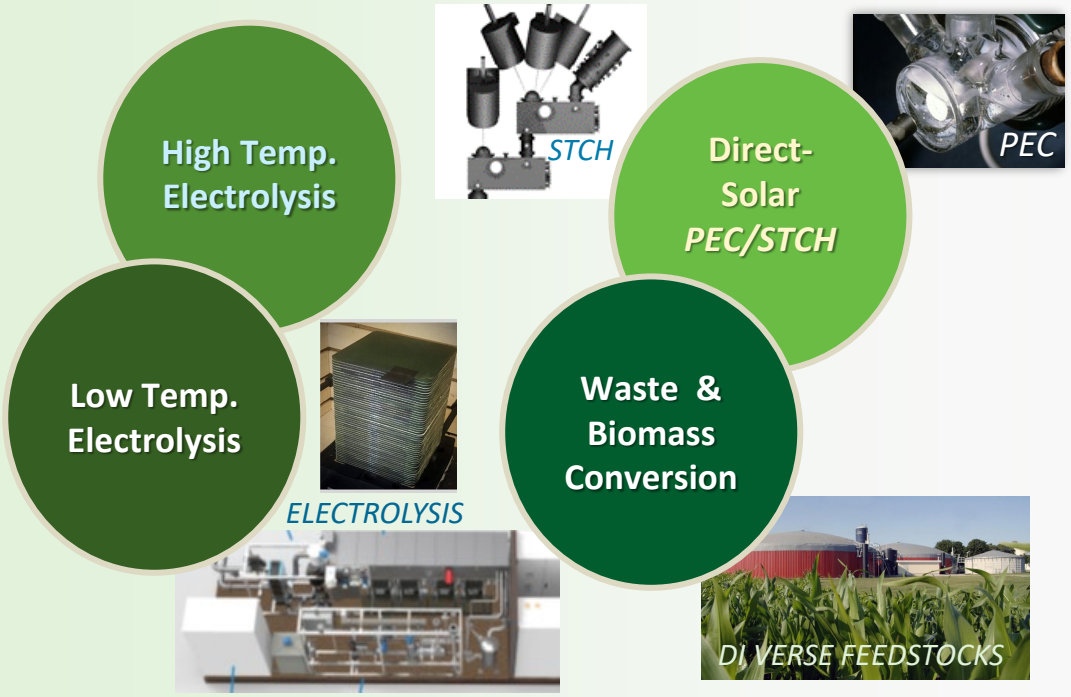
H_2 Production subprogram directly supports the National Clean Hydrogen Strategy and Strategic Priority #2





Near- to Mid-Term	Longer-Term
▪ *Water splitting through low- and high-temperature electrolysis leveraging clean & renewable energy resources*	▪ *Microbial-based conversion of bio- and waste-stream feedstocks* ▪ *Solar thermochemical (STCH and photoelectrochemical (PEC) water splitting*



Focus on hydrogen production pathways that utilize renewable/clean resources

Hydrogen Production Strategic Priorities

HYDROGEN PRODUCTION	Fuel Cell Technologies	Systems Development & Integration
Hydrogen Infrastructure 	Materials & Components Systems 	Transportation Industrial & Chemical Applications Energy Storage & Power Generation 

Systems Analysis | **Safety, Codes and Standards**

Hydrogen Production Strategic Priorities	Near-term 2025	Mid-term 2030	Longer-Term
• **Affordable, efficient and durable electrolyzers** for **GW-scale** operations • **Innovative approaches to clean H_2 production**, beyond electrolysis			

Cross-cutting/enabling: manufacturing, supply chain, workforce, regional clean H_2 networks

Clean H_2 Electrolysis Program Cost Target	**2026**	**$2/kg H_2**
Hydrogen Energy Earthshot Cost Target	**2031**	**$1/kg H_2**

The Hydrogen Production Team

Acting Program Manager

David Peterson

Technology Managers

McKenzie Hubert

Anne Marie Esposito

Elias Pomeroy

James Vickers

Kat Rinaldi

Support Contractors

Leah Mcgovern

David Aguerrebere

Corey Schaffer

Technical Project Officer

Kim Cierpik-Gold

Fellows

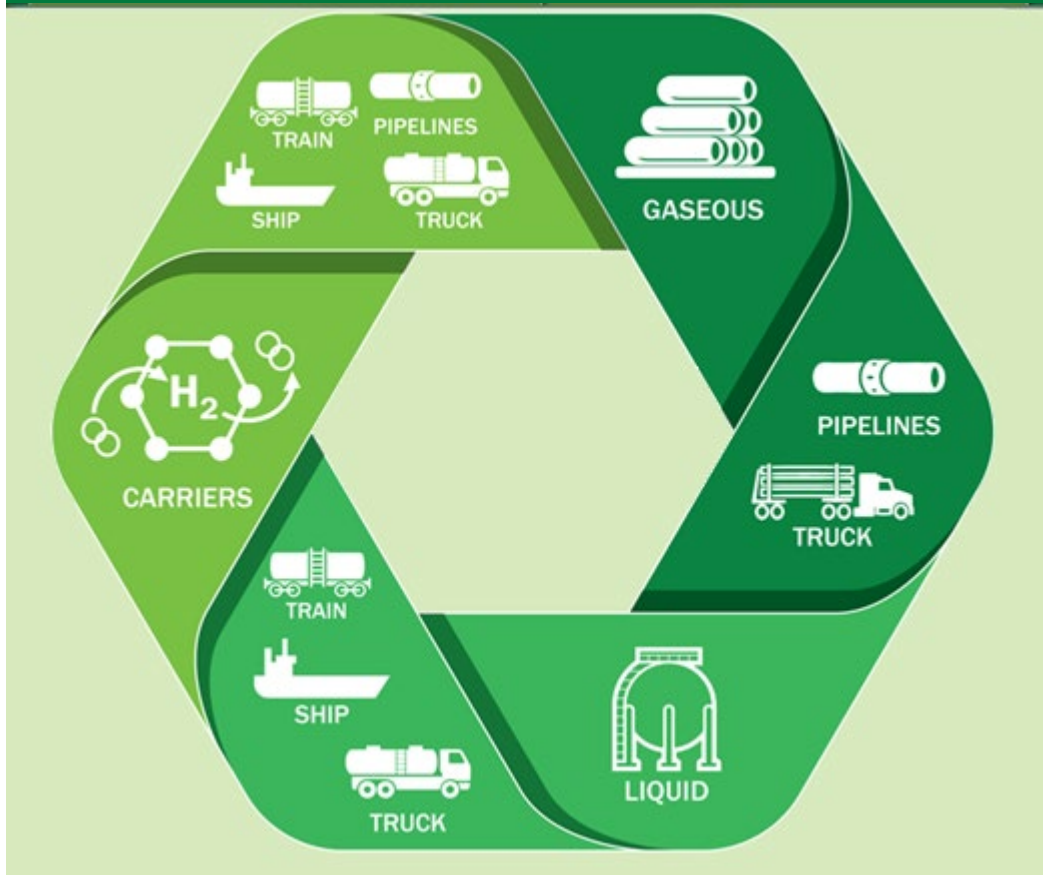
Open Position

Open Position

H_2 Infrastructure Technologies Subprogram

Mission: To carryout RD&D activities to develop H_2 infrastructure technologies to enable achieving the National Hydrogen Strategy and decarbonization goals

Infrastructure Technologies



Hydrogen may be moved or stored as a gas, cryogenic liquid, or materials-based carrier

- **H_2 Conditioning:** compression, liquefaction/vaporization, H_2 carrier hydrogenation/dehydrogenation, purification
- **H_2 Transmission/Distribution:** on-road trailers, pipelines, rail, marine, bulk storage, transfers, sensors/monitoring
- **H_2 Dispensing:** dispensers, nozzles/receptacles, breakaways, temperature control, cascade storage, compressors, pumps
- **End-Use:** on-site, on-vehicle storage

Infrastructure pathways may take place on a single property, a region, or across multiple continents (e.g., international export)

The Hydrogen Infrastructure Technologies – Team Fantastic

Program Manager

Ned Stetson

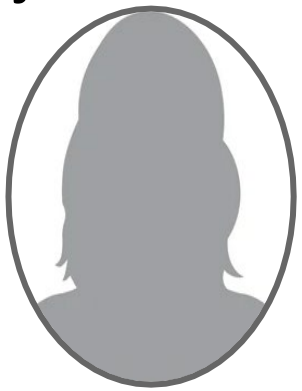
Technology Managers/Technical Project Officers

Mark Richards

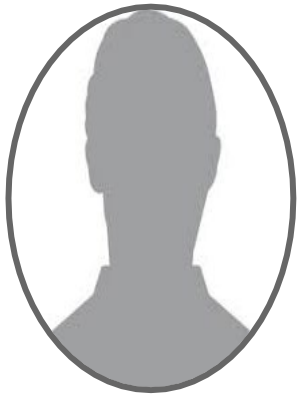
Marika Wieliczko

Zeric Hulvey

Kevin Carey



New TM/TPO



New TM/TPO

ORISE Fellows

Asha-Dee Celestine

Zakaria Hsain

Lab Detailee

Abhi Karkamkar

Support Contractors

Josh Farley

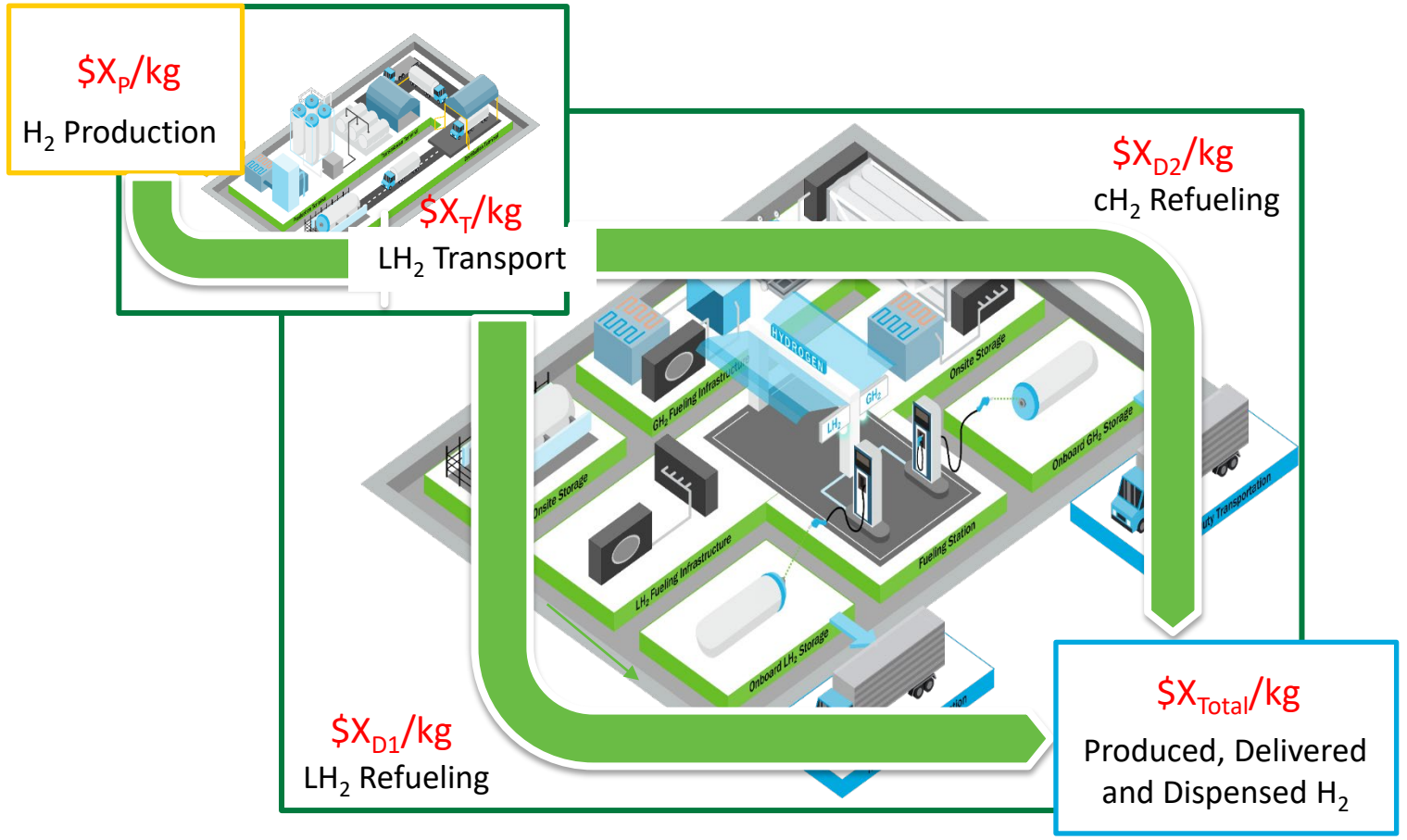
Nikkia McDonald

Haboon Osmond

To Meet Decarbonization Goals – Focused on Three Sectors

- Medium & Heavy-Duty Transportation
- Chemical & Industrial Processes
- Energy Storage
- ***Developing Scenarios for Each***

Key Metric: Cost of Hydrogen to the End Users



Example: MD/HD Refueling

Assume LH_2 delivery to stations in near-term

Need to consider both cH_2 and LH_2 onboard storage

Strategic Focus Areas

- Analysis
- Materials
- Liquefaction
- Cryopumps
- Compression
- Storage

Hydrogen Infrastructure Technologies Strategic Priorities

HYDROGEN Infrastructure

Hydrogen Production

Fuel Cell Technologies

Materials & Components

Systems

Systems Development & Integration

Transportation

Industrial & Chemical Applications

Energy Storage & Power Generation

Systems Analysis

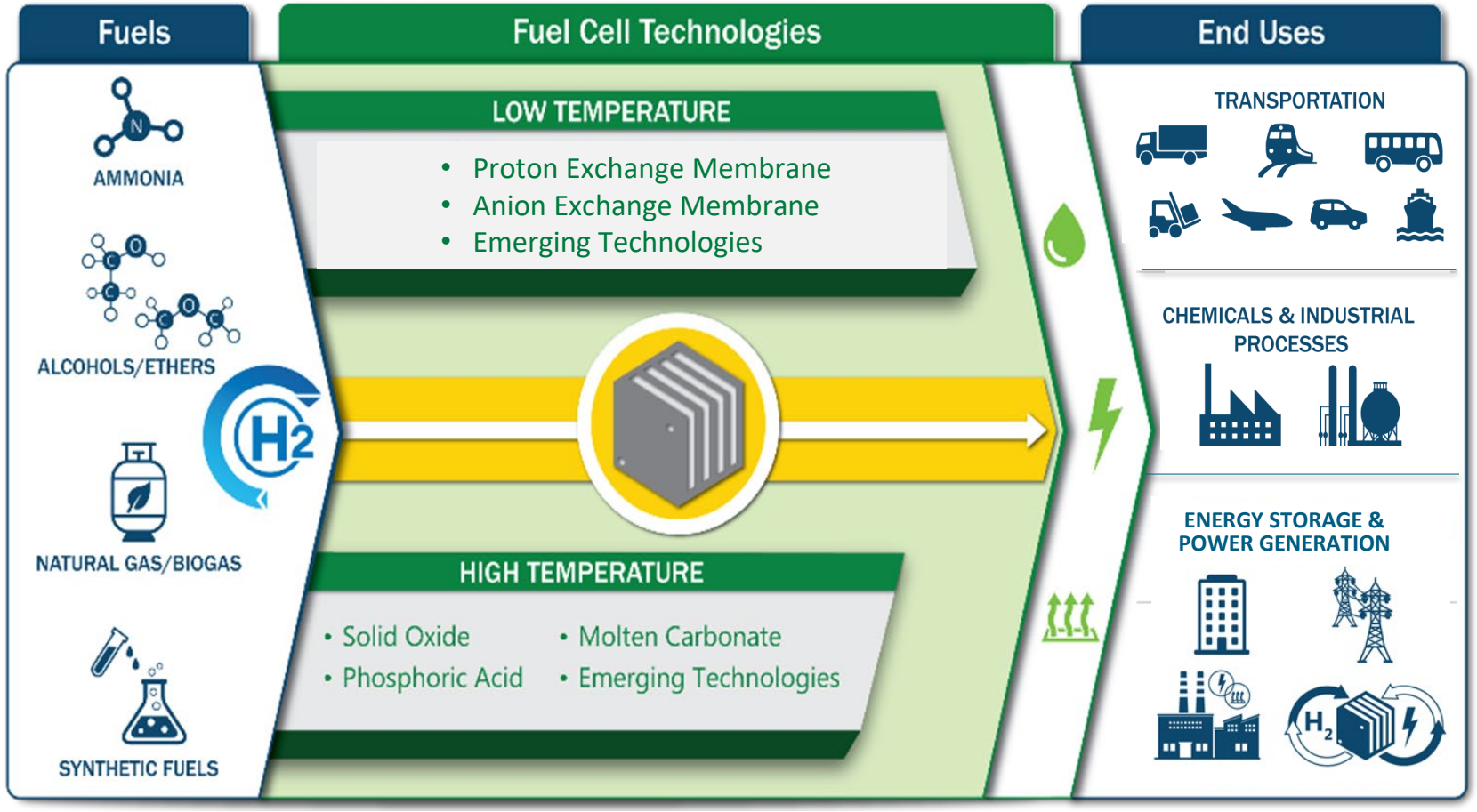
Safety, Codes and Standards

Hydrogen Infrastructure Strategic Priorities	Near-term 2025	Mid-term 2030	Longer-Term
• Affordable and reliable components and systems for **H_2 transport and dispensing in heavy-duty applications** • **Advanced H_2 liquefaction and carrier distribution concepts** • **Low-cost vessels** for high-pressure gaseous and cryogenic liquid H_2 storage • **Innovative H_2 storage materials** for high-density, low-pressure storage			

Cross-cutting/enabling: manufacturing, supply chain, workforce, regional clean H_2 networks

Dispensed H_2 Cost Target	2028	$7/kg H_2
	Ultimate	**$4/kg H_2**

Fuel Cell Technologies Subprogram



Goal

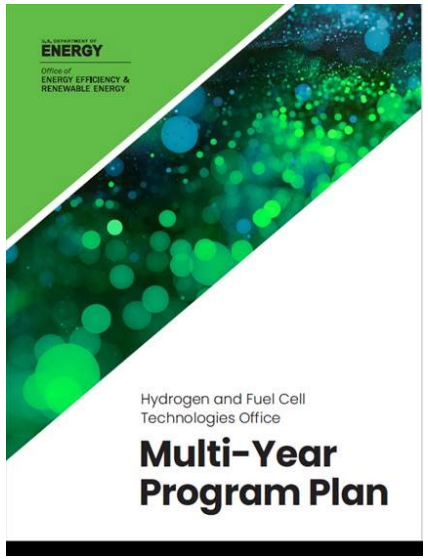
Fuel cells that are competitive with incumbent and emerging technologies across applications

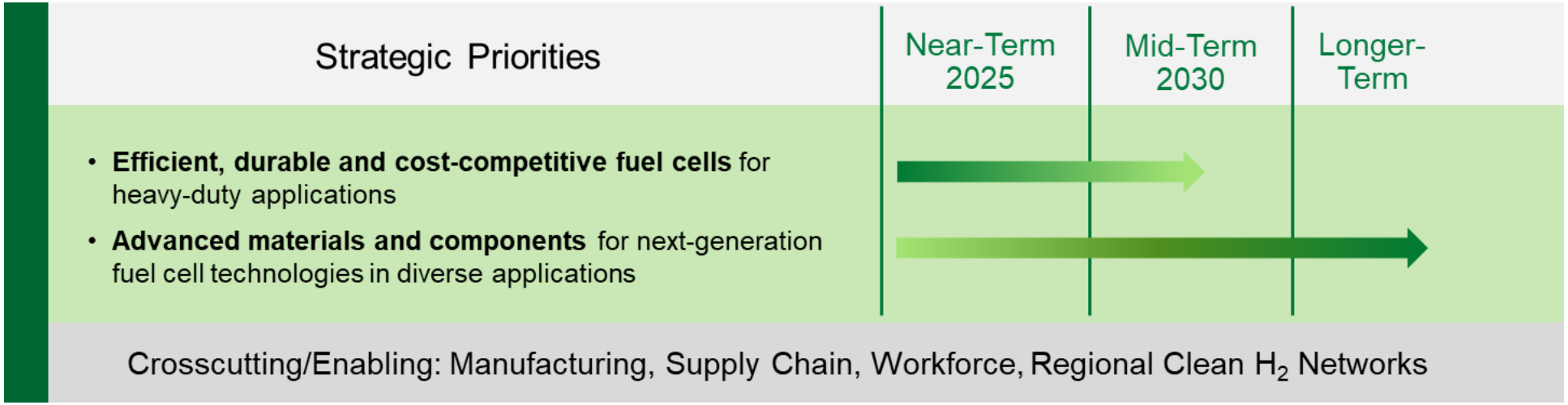
Efforts support clean H_2 end-use and broader market adoption objectives as outlined in the DOE National Clean Hydrogen Strategy and Roadmap

Fuel cells use a wide range of fuels and feedstocks; deliver power for applications across multiple sectors; provide long-duration energy storage for the grid in reversible systems.

DOE National Clean Hydrogen Strategy and Roadmap (energy.gov)

Fuel Cell Technologies – Strategic Priorities





Includes baselines and targets that are periodically assessed and adjusted as needed based on updated information, analysis, and stakeholder feedback

End Use	2023 Status	2030 Target	Ultimate Target
Heavy-Duty Transportation	•Cost $170/kW •Durability >10,000 h •Peak efficiency 64% •PGM loading >0.4 mg/cm^2	•Cost $80/kW •Durability 25,000 h •Peak efficiency 68% •PGM loading ≤0.3 mg/cm^2	•Cost $60/kW •Durability 30,000 h •Peak efficiency 72% •PGM loading ≤0.25 mg/cm^2

The Team

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Scan for Open Positions

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Technical Project Officer

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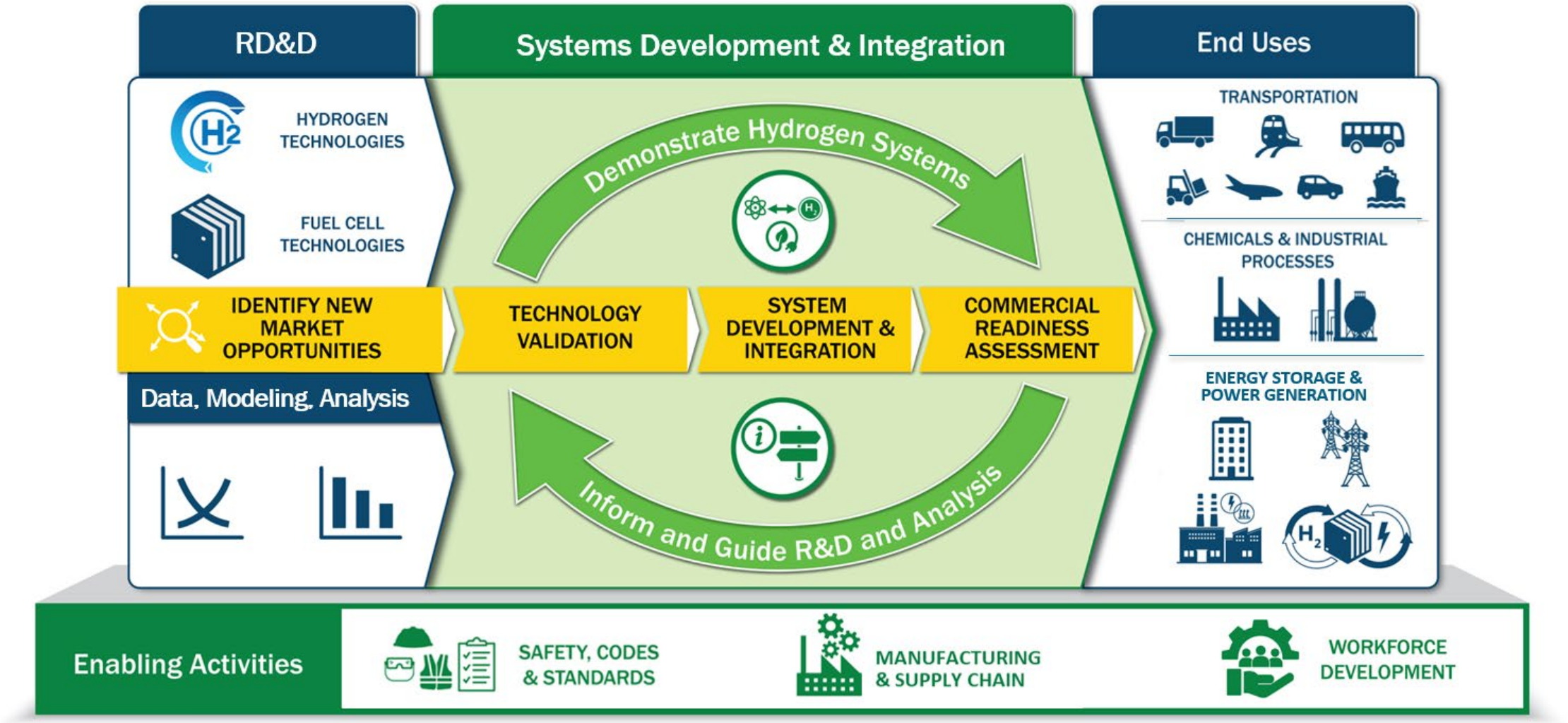
Systems Development & Integration Subprogram Overview



Bridging the Gap Between R&D and Deployments with First-of-a-Kind Integrated H_2 Demonstrations

Strategic Priorities – Guiding SDI RD&D

SYSTEMS DEVELOPMENT & INTEGRATION

Transportation

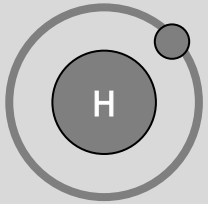
Industrial & Chemical Applications

Energy Storage & Power Generation

Hydrogen Technologies

Hydrogen Production

Hydrogen Infrastructure



Fuel Cell Technologies

Materials & Components

Systems

Systems Analysis

Safety, Codes and Standards

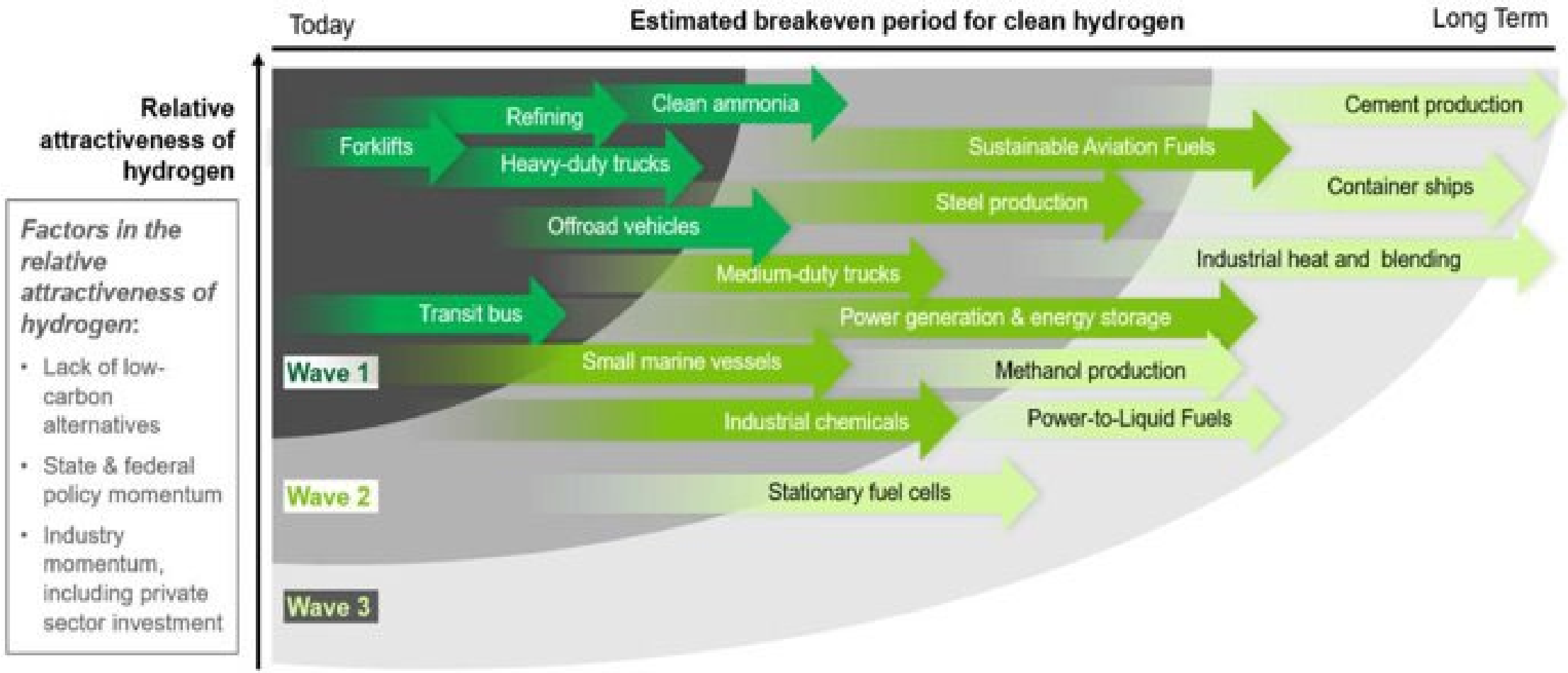
Strategic Priorities

Near-term 2025	Mid-term 2030	Longer Term

- **Transportation and H_2 fueling** demonstrations
- **Chemical and industrial processes** integrating H_2 technologies focusing on decarbonization
- **Energy storge and power generation** including Integrated and resilient hybrid energy systems

Cross-cutting: manufacturing, supply chain, workforce development, regional clean H_2 networks

Strategic Priorities – Guiding SDI RD&D



Systems Development & Integration (SDI) Team

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Tom Jacbos
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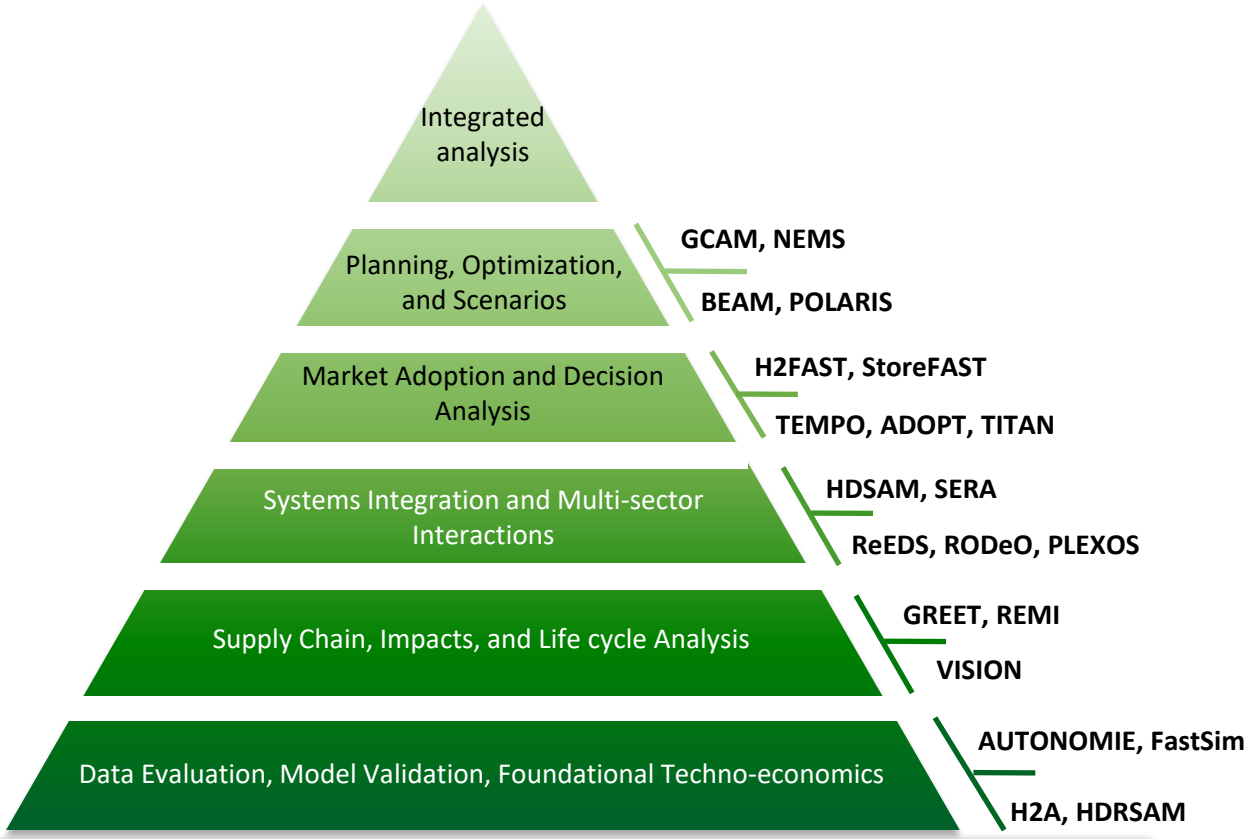
Analysis, Codes & Standards Subprogram Overview

Enabling activities to inform research, development, demonstrations and deployments



Systems Analysis identifies priority markets for hydrogen technologies and assesses impacts

Safety, Codes, & Standards informs safe design and operation of technologies, and addresses regulatory and permitting challenges.

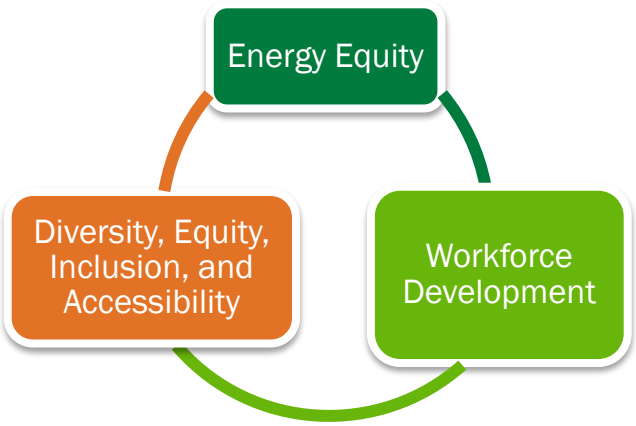
Analysis, Codes & Standards Priorities

Data, Modeling, Analysis

Strategic Priorities	Near-term 2025	Mid-term 2030	Longer-term
• **Tools, Modeling & Analysis** to prioritize RD&D and inform early-market deployments	→		
• **Regional Analysis** to support energy transition planning and assess impacts		→	
• **Integrated Analysis** to inform supply chain expansion and sustainable market growth			→

U.S. National Clean Hydrogen Strategy and Roadmap

Cross-cutting EJ Priorities

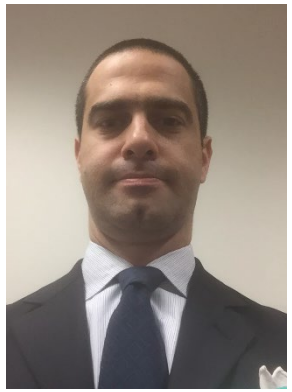


Safety, Codes and Standards

RD&D Priorities	Near-term 2025	Mid-term 2030	Longer Term
• **Codes and standards** to enable global harmonization, safety, and commercial readiness	→	→	→
• **Prioritize safety** by sharing resources, best practices, and lessons learned	→	→	→

The Dream Team!

Systems Analysis Sub-Program



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QUESTIONS?

Let's Ask the Team!

AMR: HFTO Subprogram Tracks

DOE Hydrogen Program 2024 AMR Program-at-a-Glance

Topic	Monday, May 6		Tuesday, May 7							Wednesday, May 8							Thursday, May 9			
			Hydrogen Production Technologies	Hydrogen Infrastructure Technologies	Fuel Cell Technologies	Systems Development and Integration	Analysis, Codes and Standards	Intra-Agency Activities		Hydrogen Production Technologies	Hydrogen Infrastructure Technologies	Fuel Cell Technologies	Systems Development and Integration	Interagency Activities	Intra-Agency Activities		Hydrogen Infrastructure Technologies	Fuel Cell Technologies	Systems Development and Integration
		Room	Regency E	Regency AB	Potomac III-VI	Regency CD	Regency F	Washington		Regency E	Regency AB	Potomac III-VI	Regency CD	Regency F	Washington		Regency AB	Potomac III-VI	Regency CD
	*All times in Eastern Time	8:00 AM	Continental Breakfast						8:00 AM	Continental Breakfast						8:00 AM	Continental Breakfast		
		8:30 AM							8:30 AM		IA013					8:30 AM	ST237		
1:00 PM	Welcome	9:00 AM	P000	IN000	FC000	SDI000	SA-SCS000	FE000	9:00 AM	P216	SCS037	FC352	TA048	IA001		9:00 AM	ST241	FC331	TA053
	Opening Remarks	9:30 AM	ELY-BIL001	IN025	FC160	TA056	SA187	FE001	9:30 AM	P218	IN043	FC363	TA037	IA002	JO000	9:30 AM	ST001	FC330	TA052
	Keynote Speeches	10:00 AM	SDI006	H2041		TA057	SA188	FE005	10:00 AM	P209	SCS042	FC327	TA030	IA003	VTO000	10:00 AM	ST235	FC355	
		10:30 AM	Break						10:30 AM	Break					WPTO000	10:30 AM	Break		
1:30 PM	Plenary	11:00 AM	P148	IN039	FC339	TA058	SA178	FE003	11:00 AM	P213	ST127	FC336	TA062	IA004	BETO000	11:00 AM	OCED001		
		11:30 AM		IN001a		SCS031	SA174	FE004	11:30 AM	P214		FC344	SDI002	IA005	WETO000	11:30 AM	OCED002		
		12:00 PM		IN001b			SA181	FE016	12:00 PM	P215	ST209	FC345	SDI001	IA006	SETO000	12:00 PM	OCED003		
3:15 PM	Break	12:30 PM	Lunch (provided)						12:30 PM	Lunch (provided)				IA007	NE000	12:30 PM	Lunch (provided)		
3:45 PM	Plenary	1:45 PM	P196	IN021	FC353	TA016	SCS019	FE002	1:45 PM	P208	ST212	FC348	TA018/SDI004	IA008	FE014a	1:45 PM	OCED004		
		2:15 PM		IN016	FC337	TA059	SCS028	FE007	2:15 PM	P210	ST213	FC347	TA028	IA009	BES000	2:15 PM	OCED005		
		2:45 PM		IN036	FC338	TA065	SCS021	FE011	2:45 PM	P212	ST217	FC346	TA039	IA010	EJE000	2:45 PM	OCED006		
		3:15 PM	Break						3:15 PM	Break				IA011	AMMTO000	3:15 PM	OCED007		
4:45 PM	Plenary	3:45 PM	P204	IN015	FC349	TA001	SCS001	FE008	3:45 PM	P211	ST218	MNF-BIL001	NE001	IA012	IEDO000	3:45 PM			
		4:15 PM	P170	IN040	FC350	TA029	SCS011	FE010	4:15 PM	P217	ST234		TA044	TA009	MESC000	4:15 PM			
		4:45 PM	P200	IN034	FC351	TA063	SCS010	FE006	4:45 PM	P205	ST242	FC354	TA051/TA060		OTT000	4:45 PM			
		5:15 PM	P179	IN035				FE009	5:15 PM	P206	ST243		TA064		ARPAE000	5:15 PM			
															EIA000				
5:30 PM	AMR Awards	5:30 PM	POSTER SESSION						5:30 PM	POSTER SESSION						5:30 PM			
	Closing Remarks																		
6:00 PM		7:00 PM							7:00 PM							7:00 PM			

Mahalo Nui Loa from Planet Earth…

On Behalf of HFTO
Thanks to All
& Welcome to AMR!

U.S. DEPARTMENT OF ENERGY

Hydrogen Program 2024 Annual Merit Review and Peer Evaluation Meeting

Michael Berube

Deputy Assistant Secretary for Sustainable Transportation & Fuels, Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

May 6, 2024