Stony Brook University

Institute of Gas Innovation and Technology

AT STONY BROOK UNIVERSITY

ADVANCED ENERGY™ Research and Technology Center

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Decarbonizing Navy's Operations: Large-Scale Hydrogen Storage and Production On-Demand

Professor Devinder Mahajan

Inaugural Director, I-GIT

https://www.stonybrook.edu/gas-innovation/

NPS Defense Energy Seminar

August 8, 2023

Topics

- My Background
- The Need for Decarbonization
- Energy Storage– Need and Options
- Hydrogen Economy
- Energy Storage Application
- Summary

My Background

Institute of
Gas Innovation
and Technology
AT STONY BROOK UNIVERSITY

- **2002- Professor,** Chemical Engineering
  2018- Inaugural Director: I-GIT
- **2011-2017- U.S. Department of State Jefferson Science Fellow**
  ENR/EB
- 2008-2015 Director, NSF I/UCRC- CBERD
- **2008-09: AIT- Thailand**
  AIT, Thailand (ASEAN Countries)
- **2002-15: Joint Appointment**

Stony Brook University

NSF

FULBRIGHT

Brookhaven National Laboratory

LOGOMARK LOGOTYPE

I-GIT: Established 2018

ADVANCED ENERGY™
RESEARCH AND TECHNOLOGY CENTER

nationalgrid

AIChE
The Global
Home of
Chemical Engineers

RAPID
Transforming Process Industries

Institute of
Gas Innovation
and Technology
AT STONY BROOK UNIVERSITY

VJ TECHNOLOGIES

EMEC
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UNIVERSITY

DANSKAMMER
ENERGY, LLC

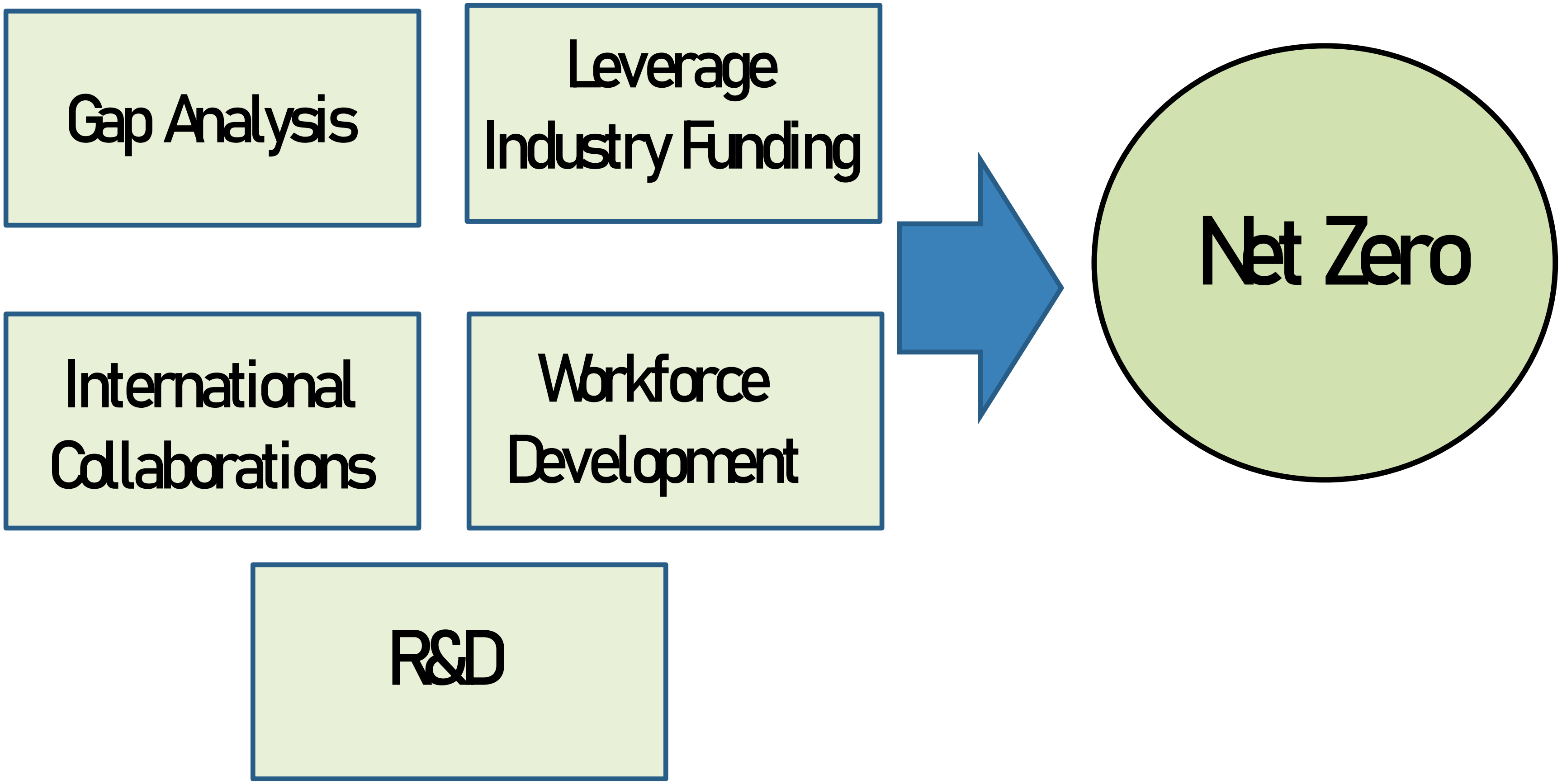
conEdison

Center for
Sustainable
Energy®

CIEES
CENTER FOR INTEGRATED
ELECTRIC ENERGY SYSTEMS
AT STONY BROOK UNIVERSITY

I-GIT Mission: Five-Pillars

Mission: Use Academic-Industry platform to accelerate deployment of advanced energy technologies and infrastructure for gas to benefit customers.



Gap Analysis

Leverage Industry Funding

International Collaborations

Workforce Development

R&D

Net Zero

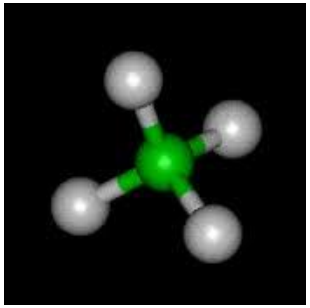
SBU Hydrogen Team

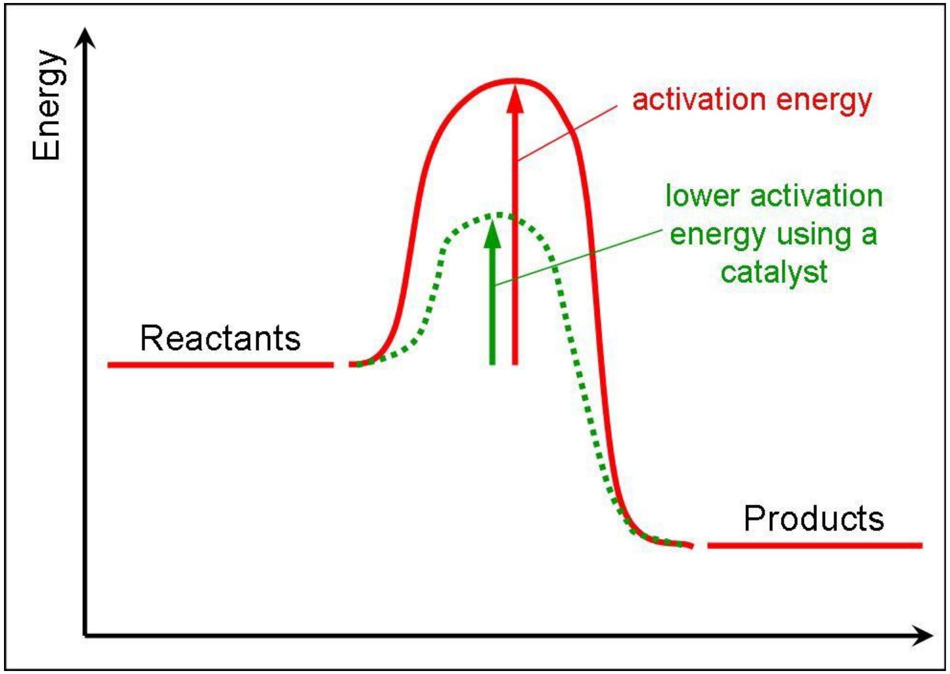
Institute of Gas Innovation and Technology
AT STONY BROOK UNIVERSITY

Name / Department	Faculty/ Department
	Clive Clayton, Mat. Sci./MSCE
Rong Zhao, CEWIT	T. Venkatesh, Mat. Sci./MSCE
Vyacheslav Solovyov, CIEEES	Peng Zhang, ECE
Karian Wright, CIE **(DEI)**	Benjamin Hsiao, Chemistry
Patricia Malone, SPD	Stanislaus Wong, Chemistry
*Devinder Mahajan, I-GIT/AERTC-MSCE	David Tonjes, Tech & Soc.
*Richard Chan, Innovation Center-CoB	Rina Tannenbaum, ChemE/MSCE
	Tad Koga, ChemE/MSCE
Students: 28	Pawel Polak, AMS- IACS
	Dimitris Assanis, Mech. Eng.
	Yue Zhao, ECE

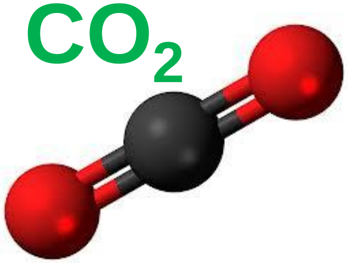
Molecules of Interest

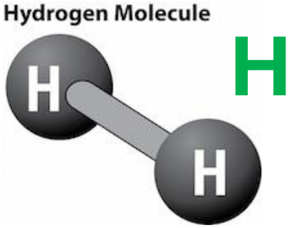
CH_4





CO_2





H_2

Interplay between three molecules

I-GIT Stats

Active Projects: 12
Personnel (Faculty/Students/Collaborators): 41
Funding Sources: [$20 million]

Other-Gifts

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

NSF

Industry

NEW YORK
STATE OF
OPPORTUNITY.
NYSERDA

Office of Naval Research
USN
ONR
Science & Technology

Topics

- My Background
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Road to Decarbonization

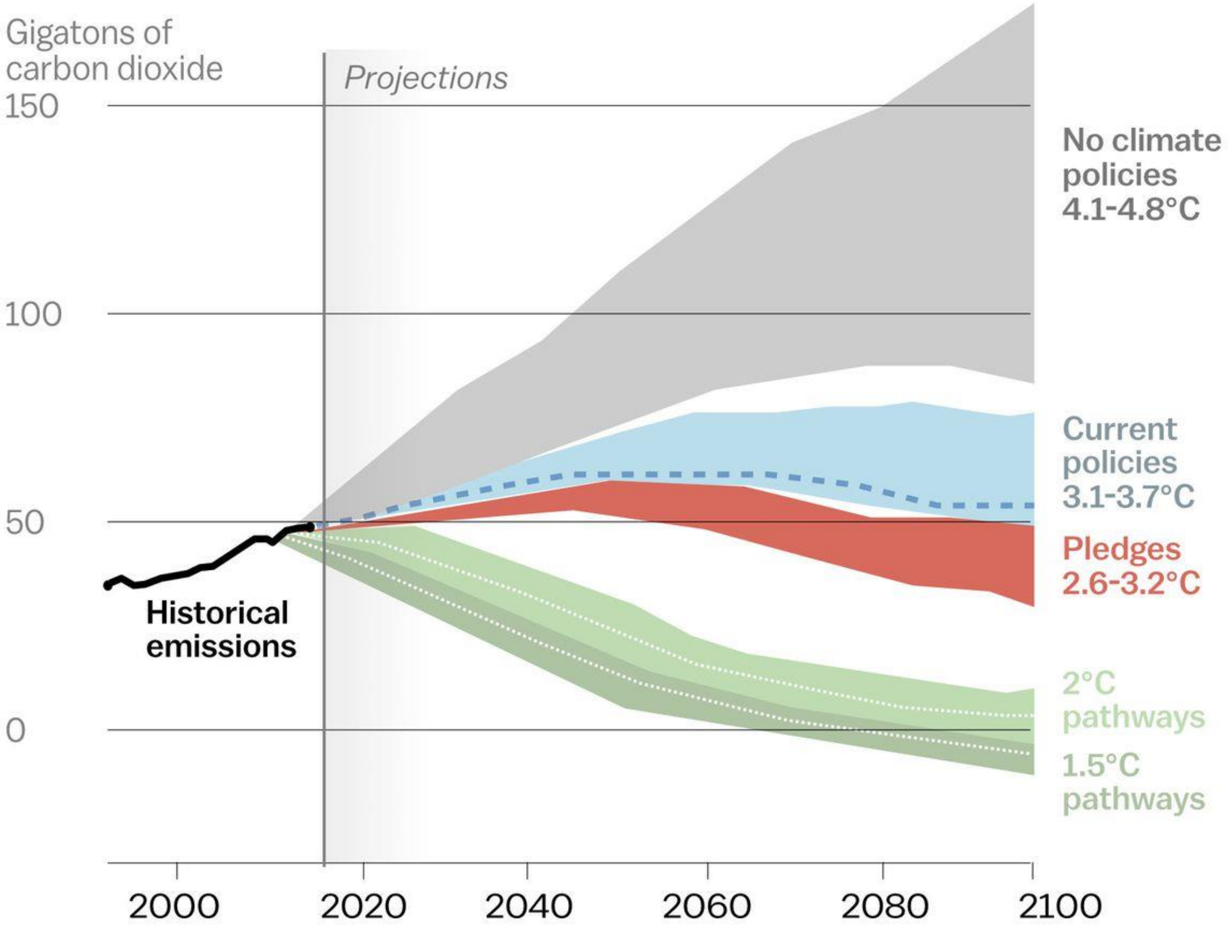
- **Global Effort**: UN Coordination to manage Greenhouse Gases (GHGs). Among GHGs, Carbon Dioxide (CO_2) and Methane (CH_4) are two key gases (atmospheric concentrations are 420 ppm and 1.7 ppm, respectively). However, CH_4 is up to 84 times (over 20-year period) more potent than CO_2.
- **CO_2 Management**. There is need not only to reduce future CO_2 concentrations, we need to reduce existing atmospheric CO2 by recycling- Utilization. The challenge is that over 70% of the CO_2 emissions are locked in the existing infrastructure.
- **United States Goal.** Achieve **net zero carbon by 2050** by substituting renewable energy sources for fossil fuels. Inflation Reduction Act (IRA) included funding for this effort. [Close to $10 billion for H_2 alone]

- DOE Goal to make H_2 competitive: [111]

Global GHGs and Policies

Effect of current pledges and policies

Global greenhouse gas emissions



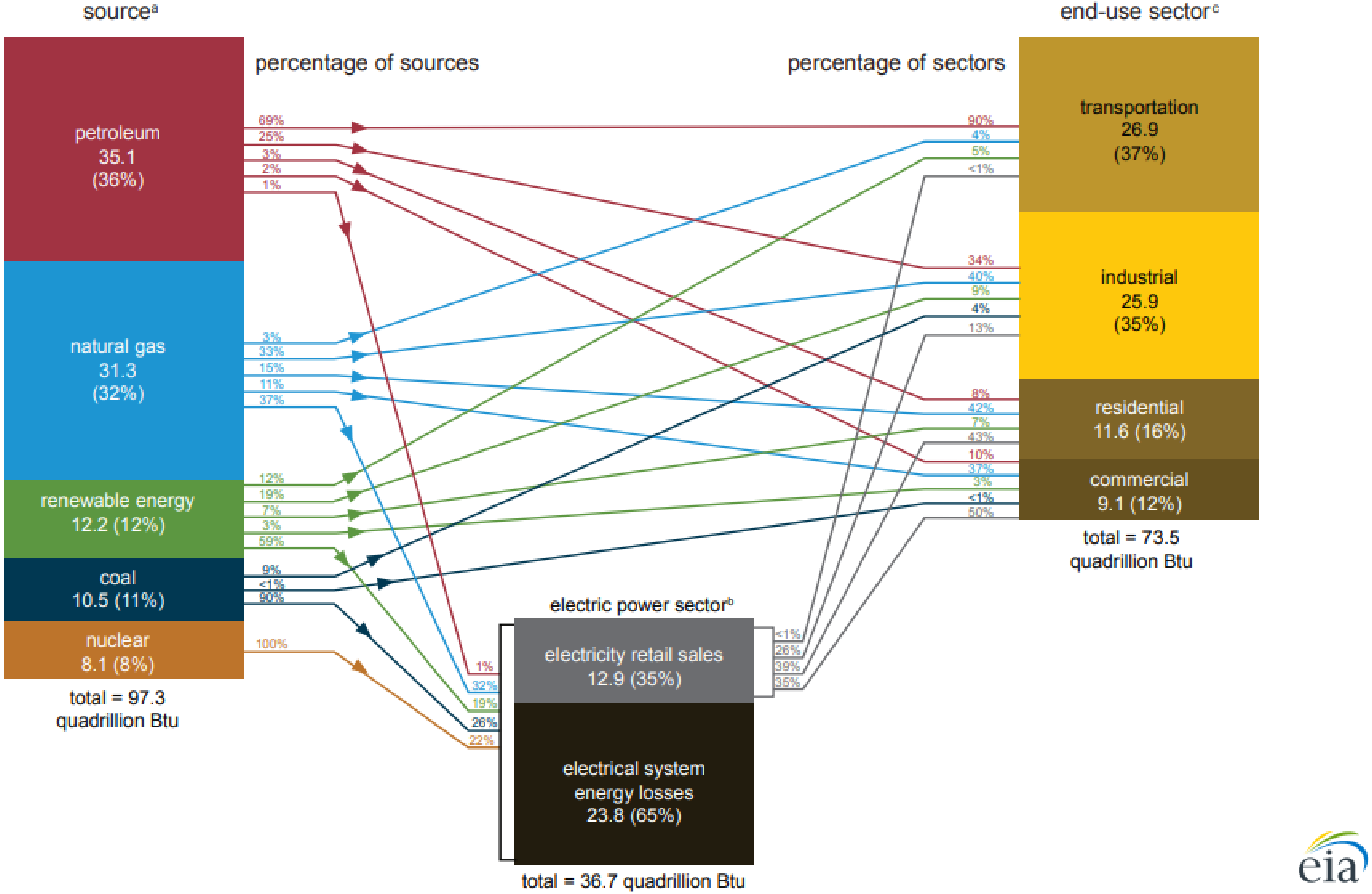
Source: Climate Action Tracker

Vox

US Energy Picture

U.S. energy consumption by source and sector, 2021

quadrillion British thermal units (Btu)



Sources: U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2022), Tables 1.3 and 2.1-2.6.

[b] The electric power sector includes electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.

Topics

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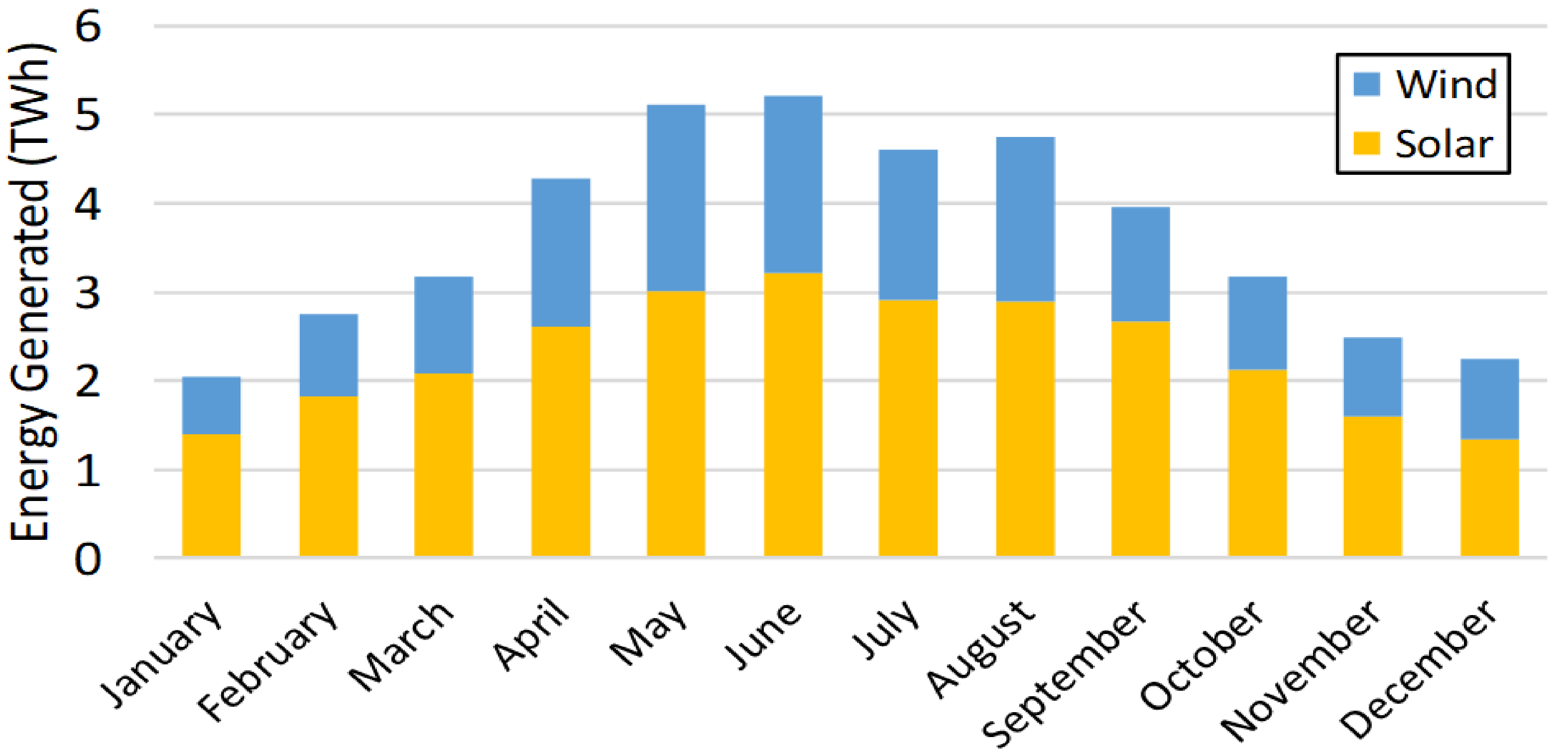
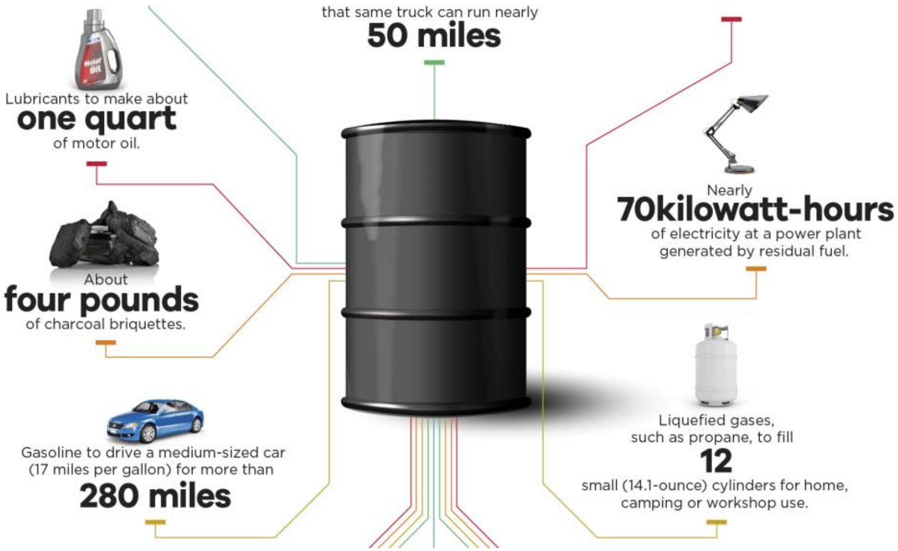
Renewable Energy- Output Variability Issue



Source: CAISO 2019

Figure. Seasonal variation of wind and solar output in California, 2018

Energy Density Issue



- Typical natural gas fired plant = 500 MW = 16 Tonnes H2
- 1 Barrel of Oil = 1,700 kilowatt-hours (kWh) of energy
- 3 kW Solar system = 8 100Ah batteries
- Windmill : 2.5 – 3 megawatts can produce in excess of 6 million kWh every year. Need 200 windmills.

❑ Energy variability and low energy density are two key challenges to implement renewables sources.

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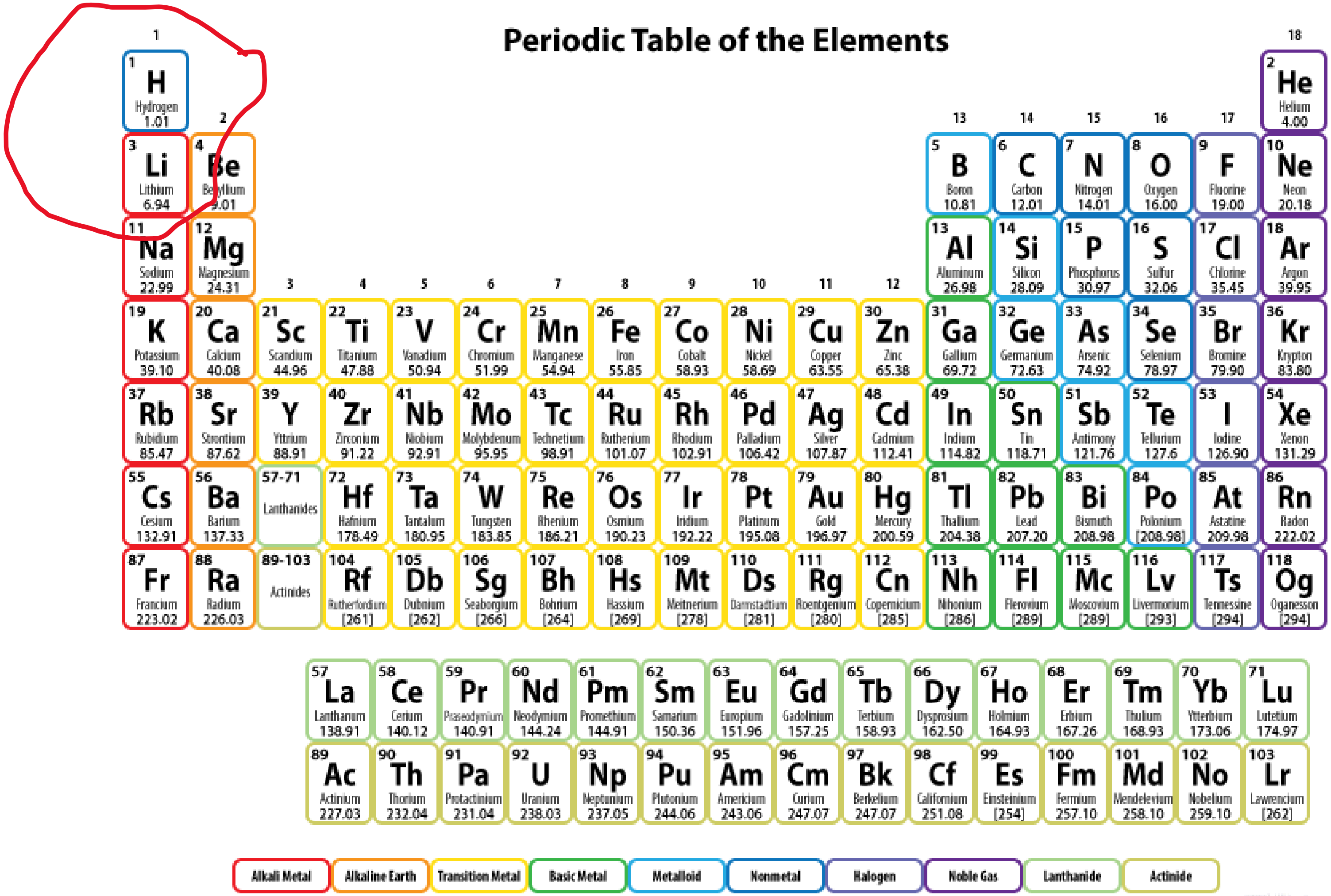
Periodic Table



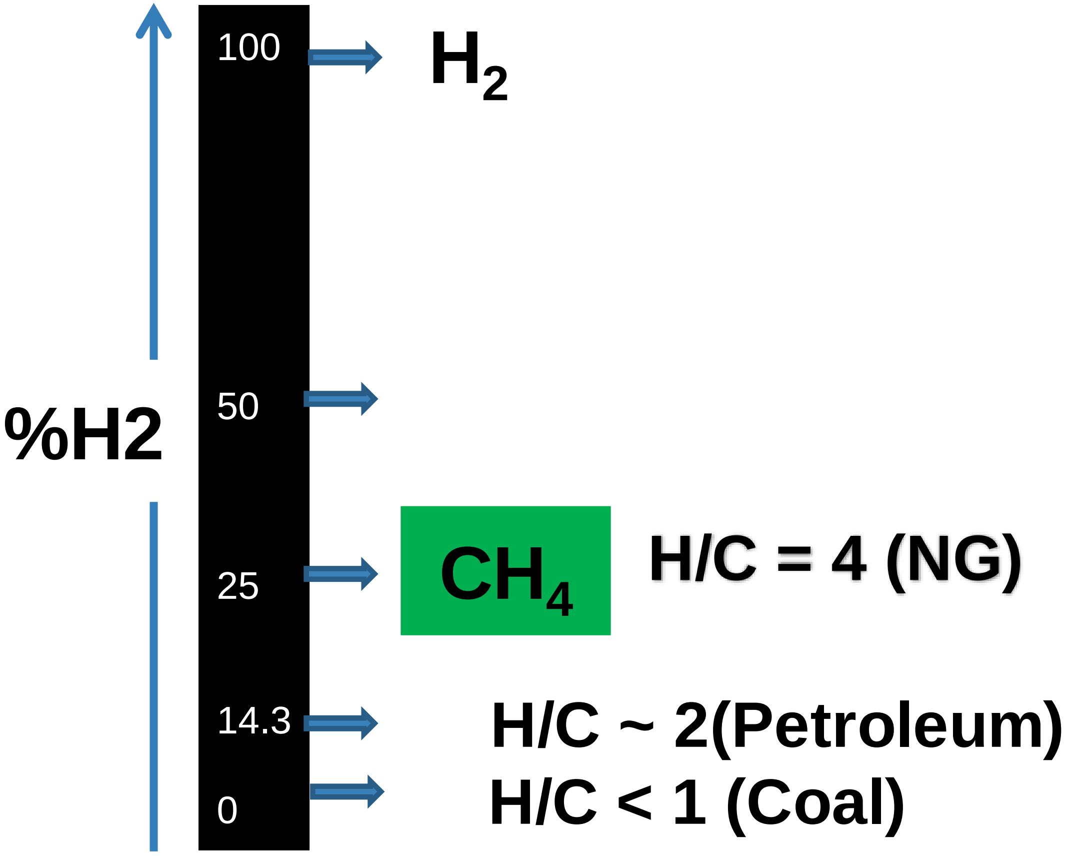
Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** Hydrogen 1.01																	2 **He** Helium 4.00
3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31											13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.06	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.88	23 **V** Vanadium 50.94	24 **Cr** Chromium 51.99	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.63	33 **As** Arsenic 74.92	34 **Se** Selenium 78.97	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.91	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.6	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57-71 Lanthanides	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.85	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.20	83 **Bi** Bismuth 208.98	84 **Po** Polonium [208.98]	85 **At** Astatine 209.98	86 **Rn** Radon 222.02
87 **Fr** Francium 223.02	88 **Ra** Radium 226.03	89-103 Actinides	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [280]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]

57 **La** Lanthanum 138.91	58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium 144.91	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.06	71 **Lu** Lutetium 174.97
89 **Ac** Actinium 227.03	90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium 237.05	94 **Pu** Plutonium 244.06	95 **Am** Americium 243.06	96 **Cm** Curium 247.07	97 **Bk** Berkelium 247.07	98 **Cf** Californium 251.08	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.10	101 **Md** Mendelevium 258.10	102 **No** Nobelium 259.10	103 **Lr** Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Metalloid | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

Transition to Hydrogen Economy



%H2

100 → H_2

50 →

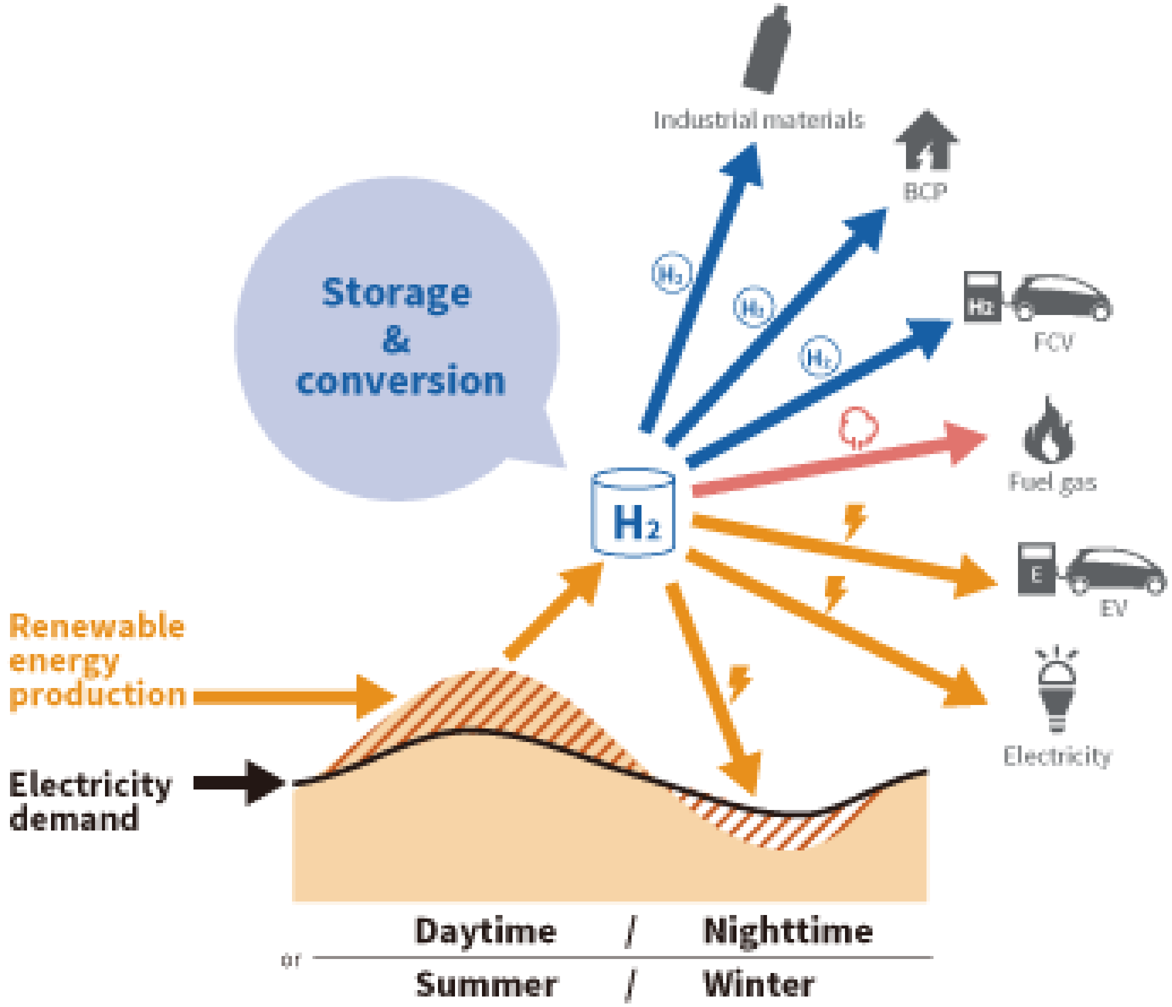
25 → CH_4 H/C = 4 (NG)

14.3 → H/C ~ 2(Petroleum)

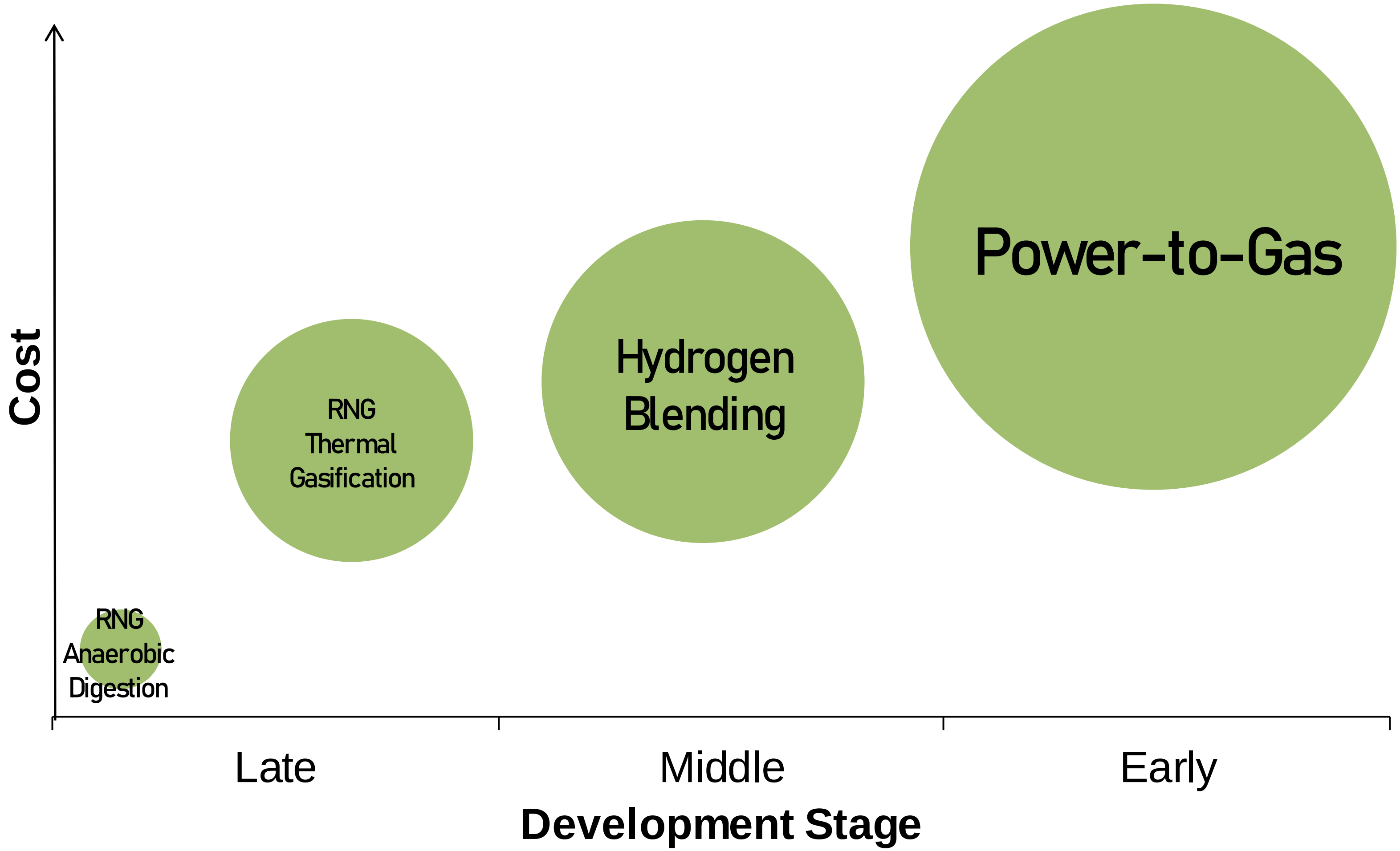
0 → H/C < 1 (Coal)

Scale is relative to H/C

Renewable Energy- Output Variability Issue



Decarbonization: Gaseous Pathways



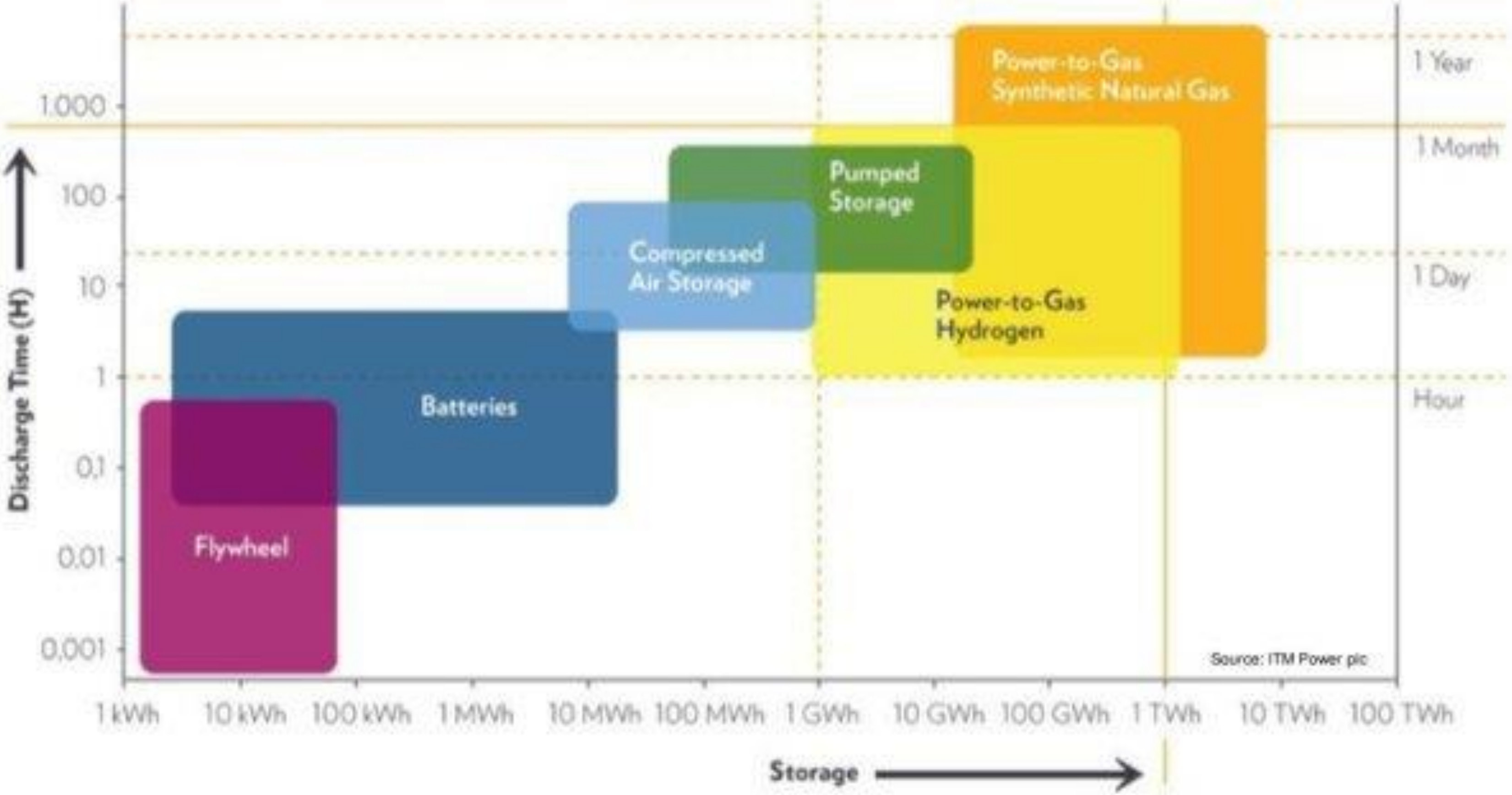
Storage

Gas	d, Kg/m3	B. pt., oC
CH4	0.657	- 160
H2	0.08375	- 252.9

Energy Storage Potential of Various Options

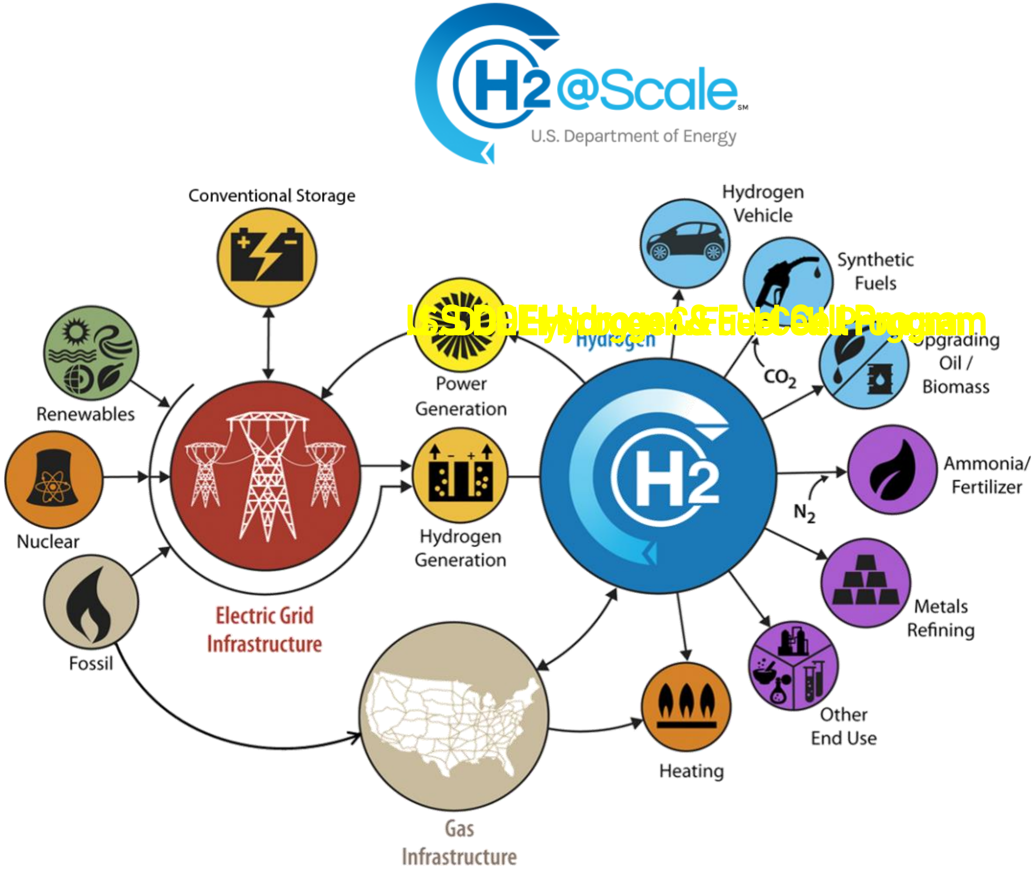
ENERGY STORAGE TECHNOLOGIES

Power-to-gas is efficient | long term | low energy cost



Source: ITM Power plc

U.S. DOE Hydrogen@Scale Program



Large-scale, low-cost H2 from diverse domestic sources

Materials innovations are key to enhancing performance, durability, and cost of hydrogen generation, storage, distribution, and utilization technologies key to H2@Scale

https://www.energy.gov/eere/fuelcells/h2scale

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Cost Comparison: Batteries vs P2G

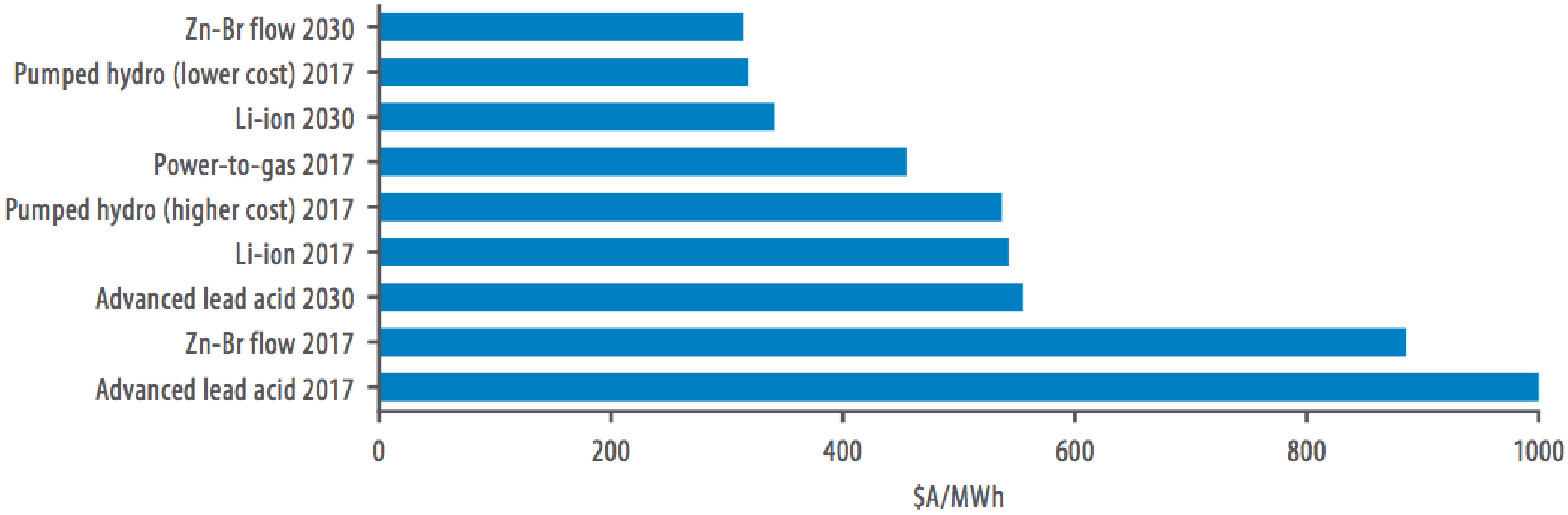


Figure 8: Indicative levelised cost of energy storage for bulk energy storage by technology ($A/MWh)

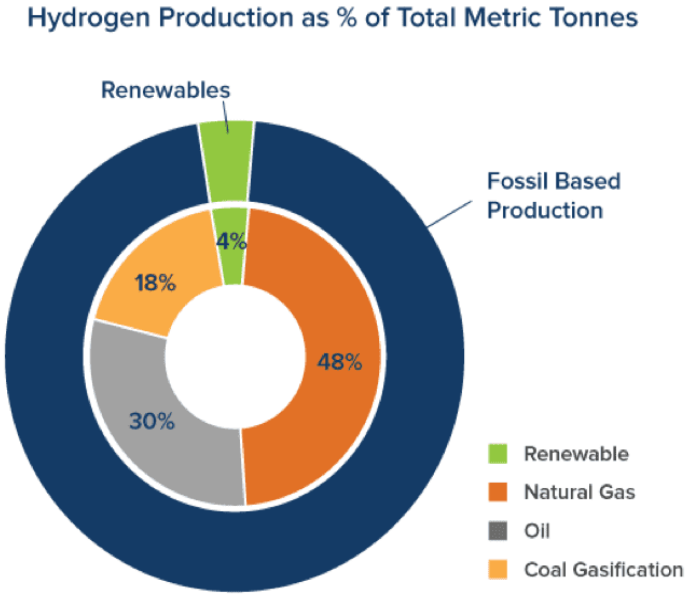
Note: Only those batteries where sufficient evidence exists of future trends have been included in this figure. The assumed electricity price is $A100/MWh. A full list of input assumptions used to calculate the levelised cost of energy is provided at Appendix 2.

Hydrogen Production: Market and Scale-up

Fossil fuels based:

1. Oxidation
2. Gasification
3. Steam methane reforming (SMR)

- Grey H2
- Blue H2 (with CCS)
- Electrolysis (Green H2)



Challenges:

- Market volume, MT/Yr: 60 (2017) to 650 in 2050
- USD: 1 Trillion
- Production, Storage, Transport

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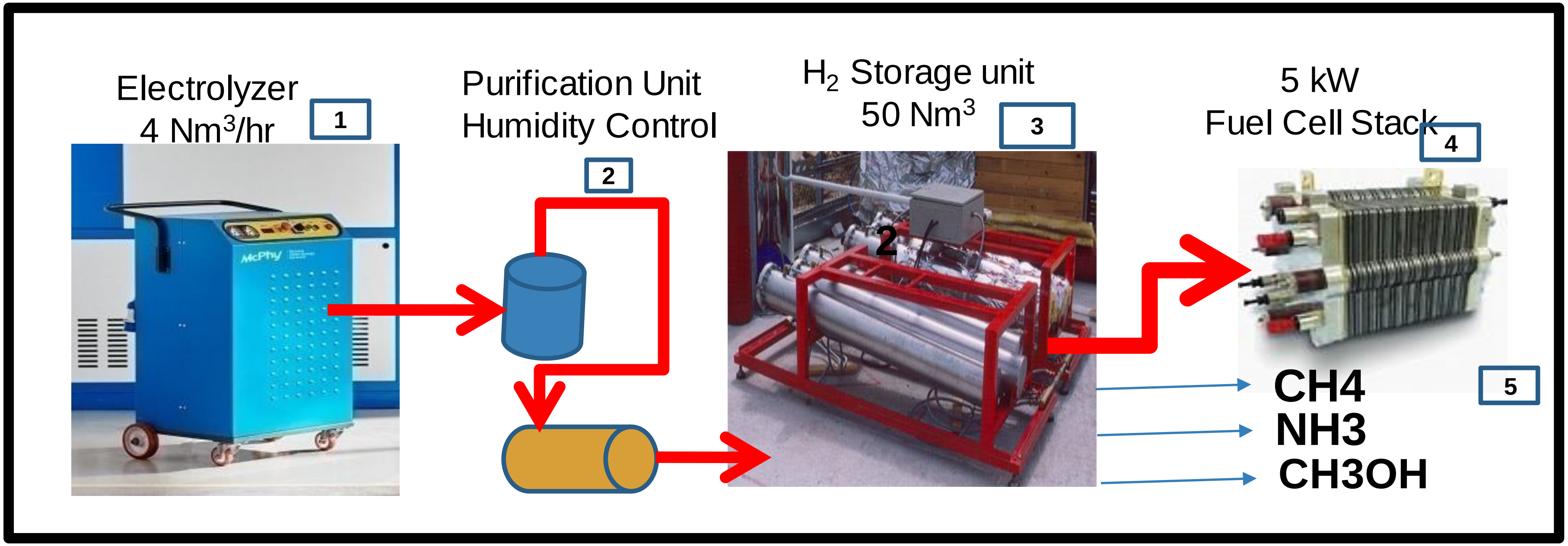
P2X: Existing and Under Development

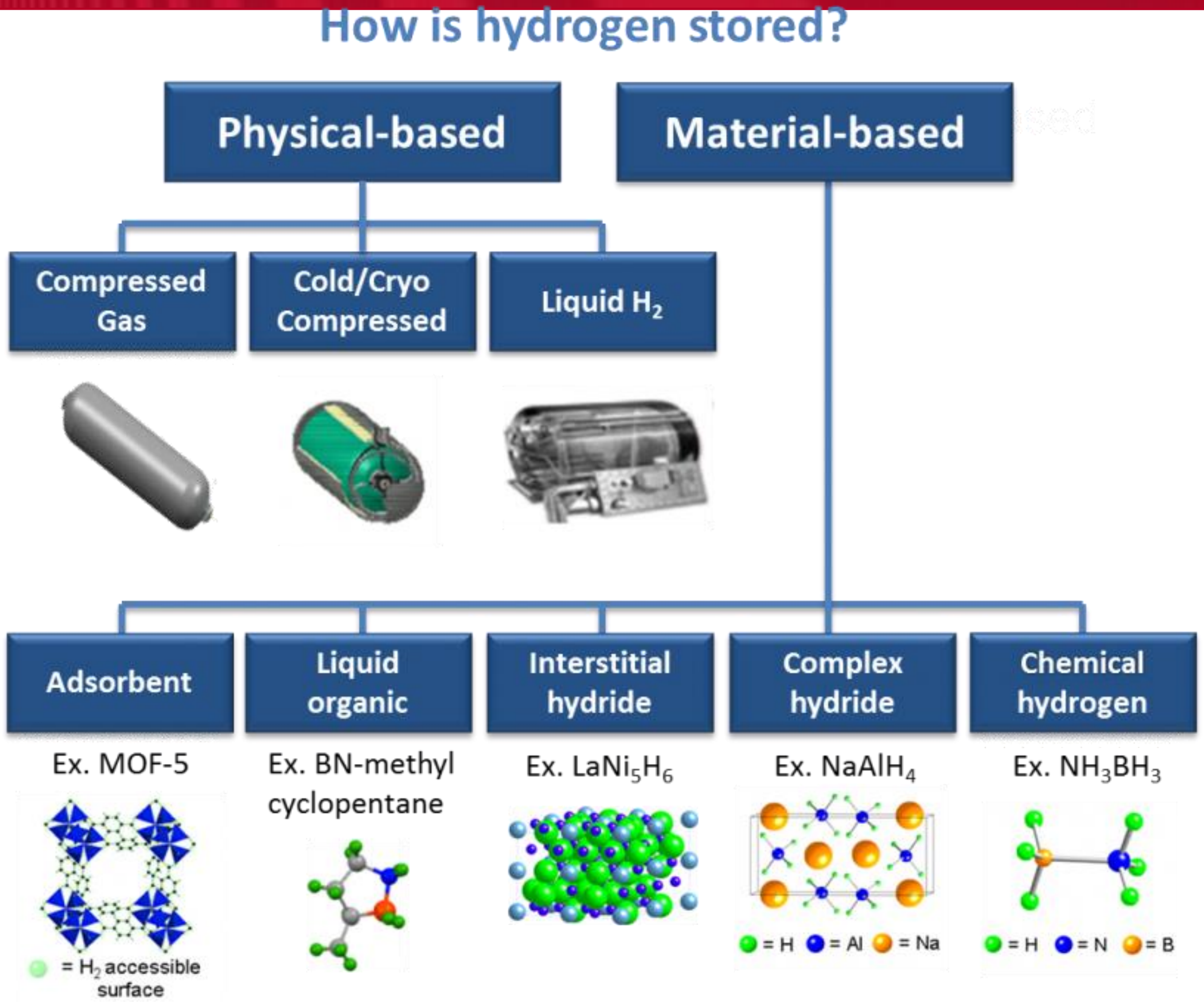


1. Electrolyzer: Novel Membranes/Heat Management; novel wastewater as feed
2. Purification Unit: Membrane H2-water vapor separation
3. Hydrogen Storage-

3a. Absorption/Desorption kinetics in metal hydrides
3b. Methanol synthesis- Liquid energy carrier
3c. Renewable methane from CO2-H2.

4. Fuel Cell- Membranes /Catalyst/Heat Management
5. P2G Unit integration- HEAT Management

Hydrogen Storage Options



How is hydrogen stored?

Physical-based

- Compressed Gas
- Cold/Cryo Compressed
- Liquid H_2

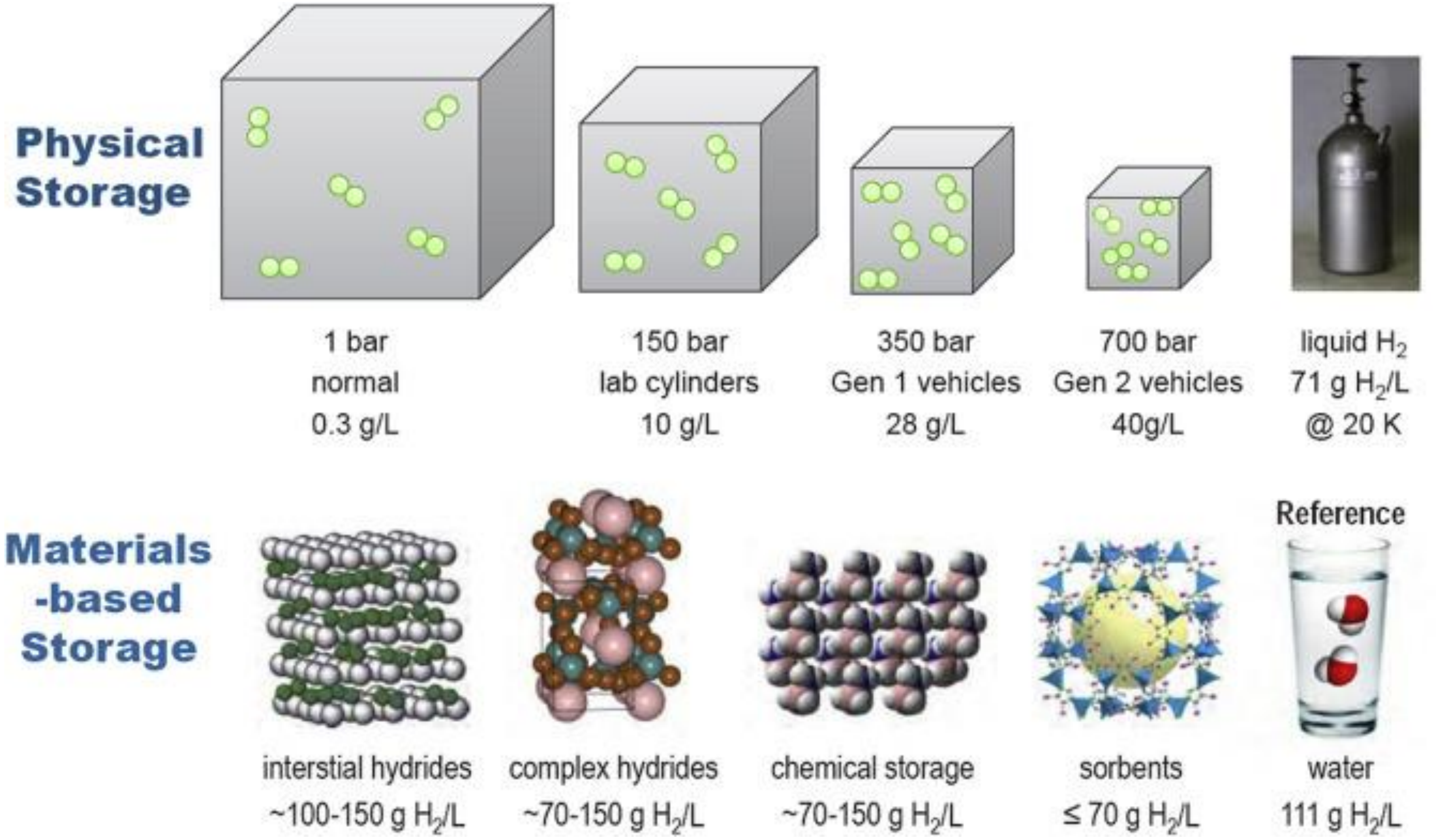
Material-based

- Adsorbent: Ex. MOF-5
- Liquid organic: Ex. BN-methyl cyclopentane
- Interstitial hydride: Ex. $LaNi_5H_6$
- Complex hydride: Ex. $NaAlH_4$
- Chemical hydrogen: Ex. NH_3BH_3

U.S. DOE

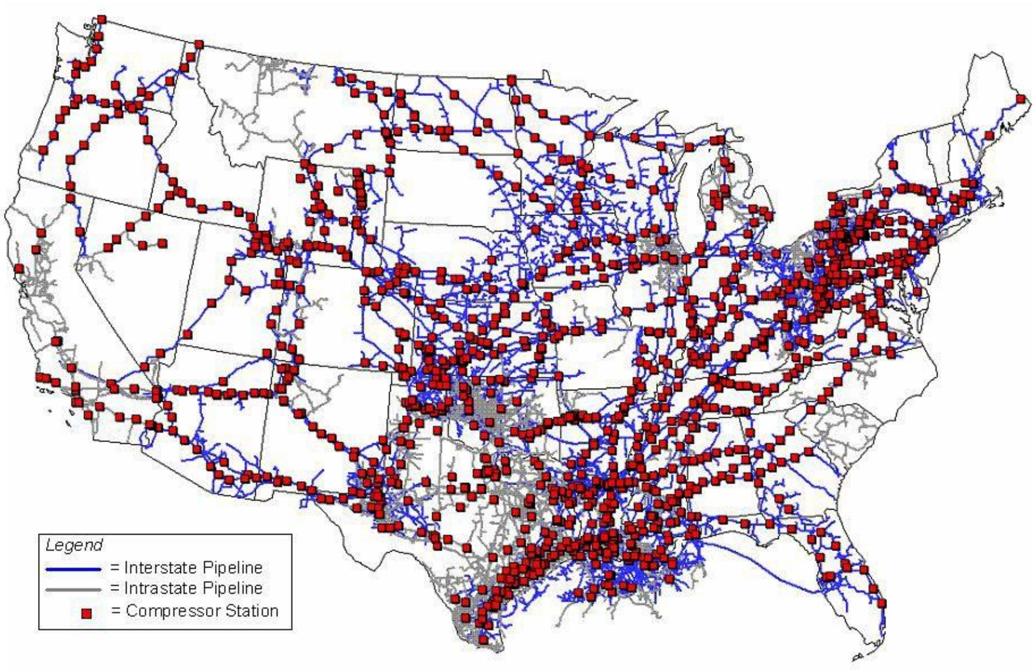
Hydrogen Storage and Transport Options

Ren et al., IJHE 42 (1), 289-311 (2017)



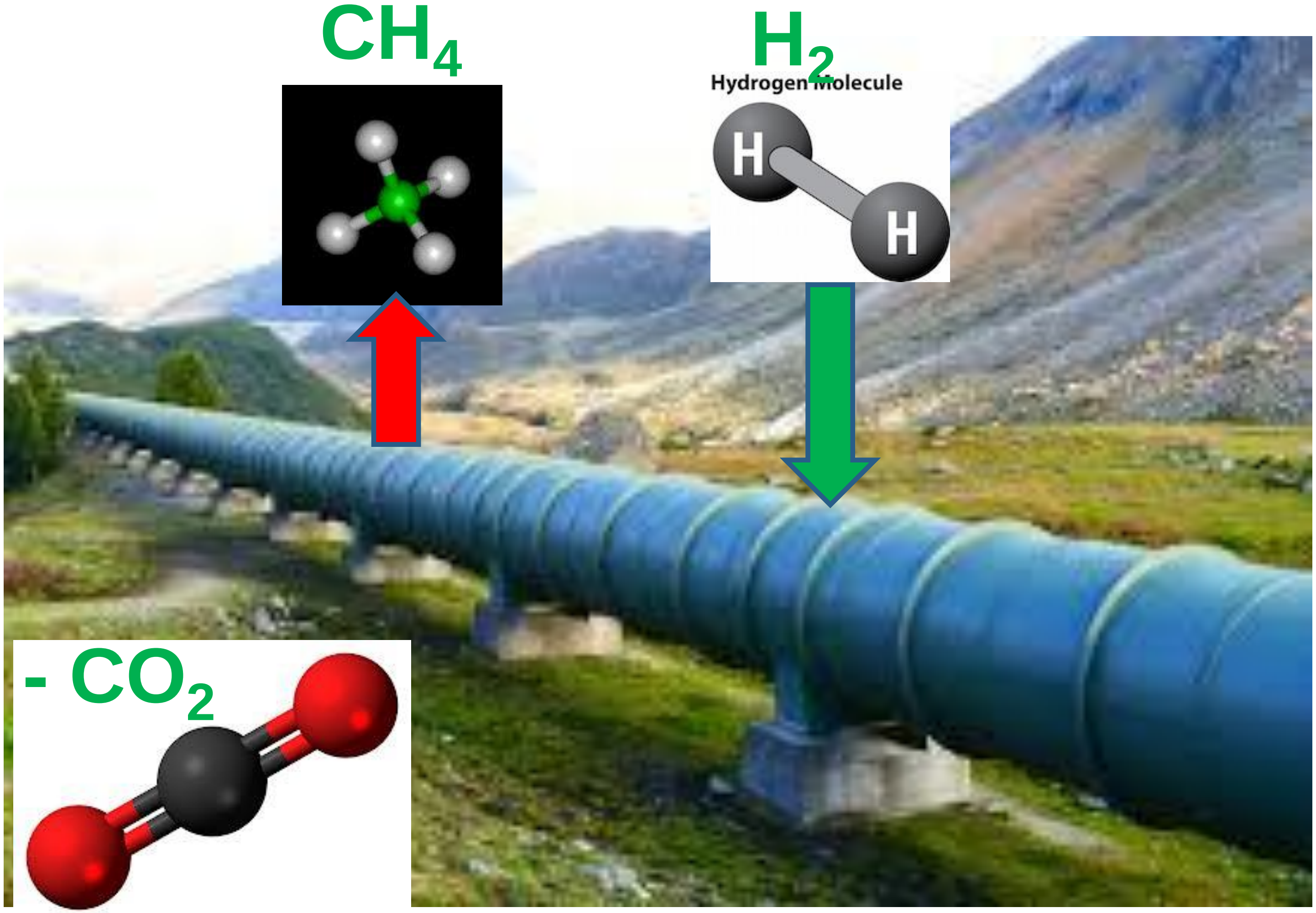
U.S. Pipeline Network

- A highly integrated network- 3 million miles of main and other pipelines.
- Delivered 28.3 Tcf gas in 2019.
- *Replacement value of outdated pipeline: $570 billion.*
- Can we repurpose this infrastructure for H_2?



Data, courtesy of:
SPE
EIA

Decarbonization in Pipeline



CH_4

H_2

$- CO_2$

Sample Testing Plan

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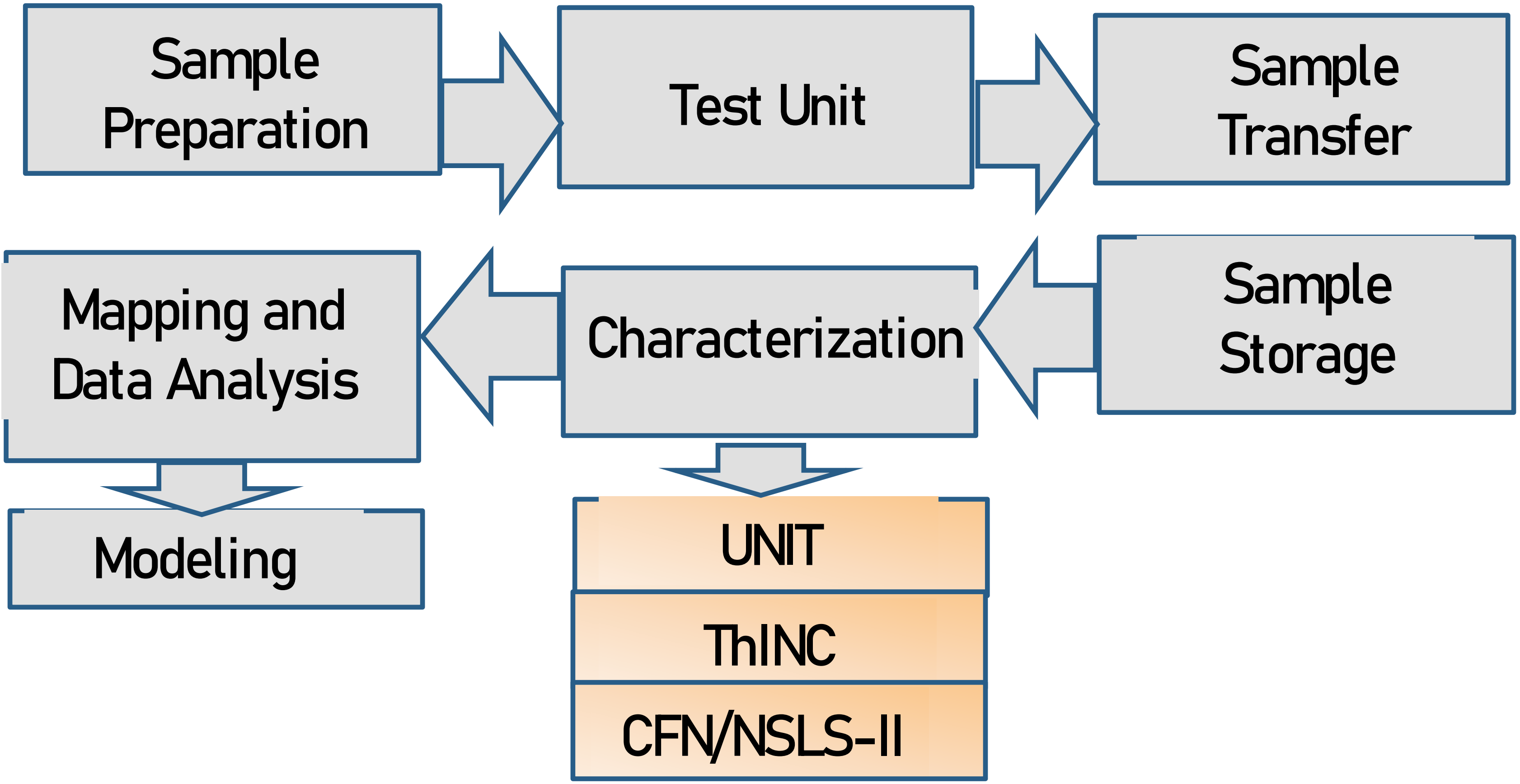


Sample Preparation

Test Unit

Sample Transfer

Sample Storage

Characterization

Mapping and Data Analysis

Modeling

UNIT

ThINC

CFN/NSLS-II

<u>Outcome</u>:

Data mapping to establish pipeline lifetime based on pipe integrity

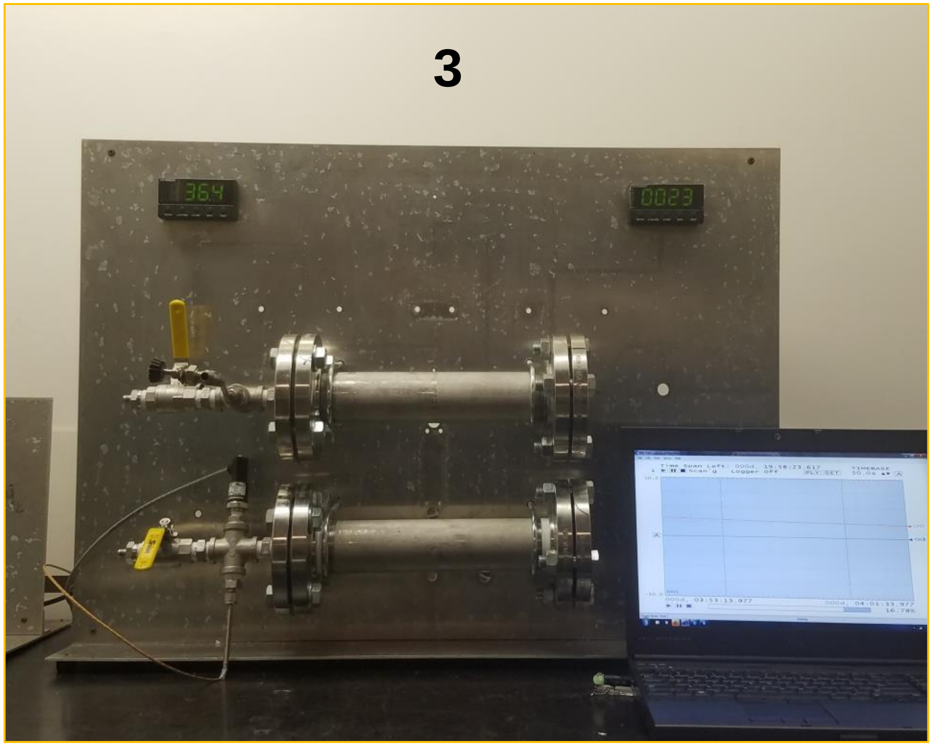
Pipeline Mimic Unit: : Effect of Hydrogen in Natural Gas Pipelines

1) Samples, 2) Sample preparation, 3) Treatment with hydrogen, 4) Sample Storage

1

2

3



4

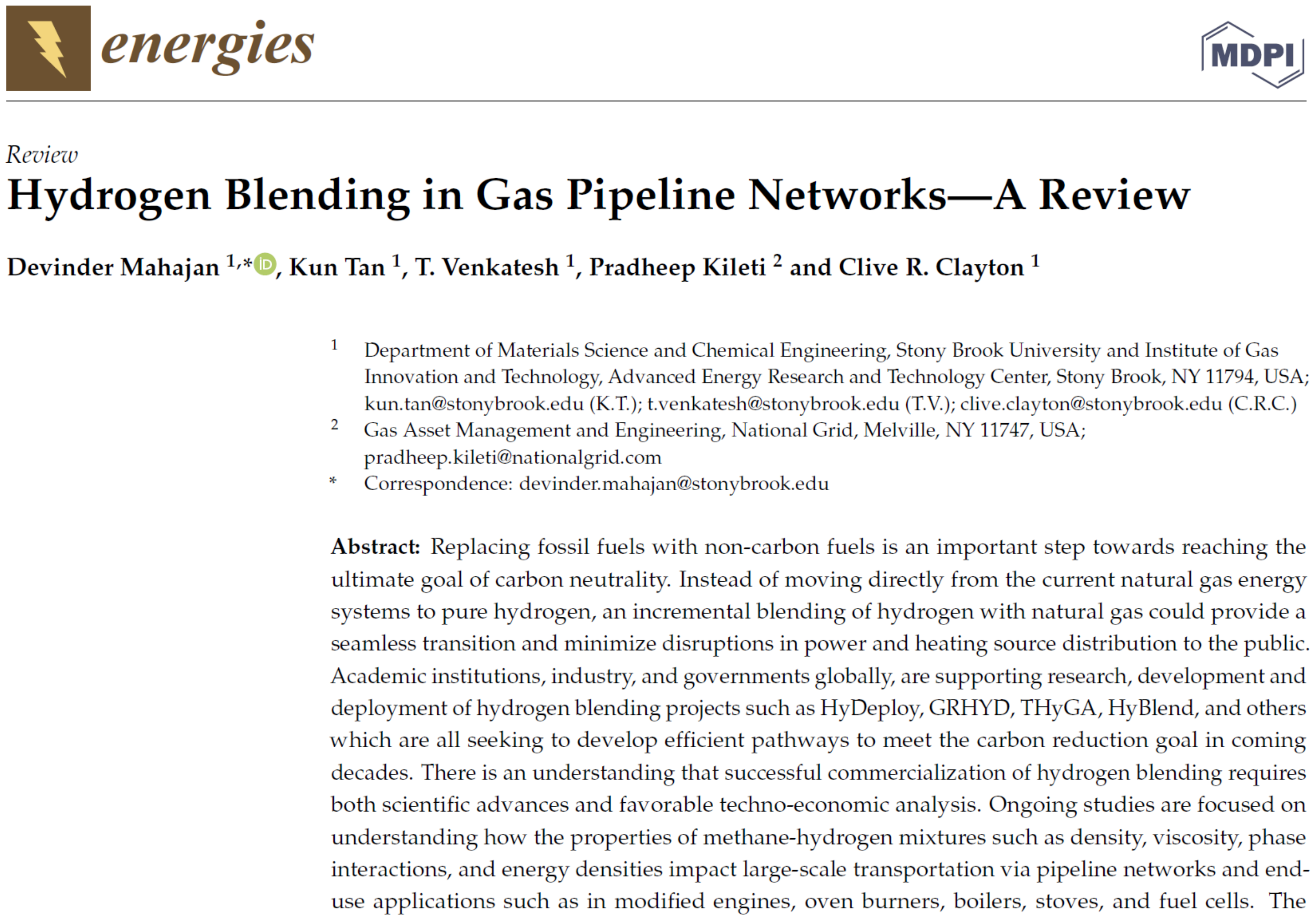
Characterization of Pipeline Samples:

Facilities at AERTC/BNL: Measure both Physical and Chemical effects of hydrogen.

Testing Techniques and Standards

		Hydrogen Pressure		
		None	Low	High
Hydrogen Hold time	None	Reference Material		
			Structural Characterization (SBU/CFN)	**Mechanical Characterization (SBU/Sandia)**
	Low		SEM TEM XRD XPS	Stress-Strain (ASTM E8) Fracture Toughness (ASTM E399) Hardness Fatigue (ASTM E466, E647)
	High			

CH4-H2 Blends in Gas Pipelines – A Review



energies

MDPI

Review

Hydrogen Blending in Gas Pipeline Networks—A Review

Devinder Mahajan [1,*], Kun Tan [1], T. Venkatesh [1], Pradheep Kileti [2] and Clive R. Clayton [1]

[1] Department of Materials Science and Chemical Engineering, Stony Brook University and Institute of Gas Innovation and Technology, Advanced Energy Research and Technology Center, Stony Brook, NY 11794, USA; kun.tan@stonybrook.edu (K.T.); t.venkatesh@stonybrook.edu (T.V.); clive.clayton@stonybrook.edu (C.R.C.)

[2] Gas Asset Management and Engineering, National Grid, Melville, NY 11747, USA; pradheep.kileti@nationalgrid.com

* Correspondence: devinder.mahajan@stonybrook.edu

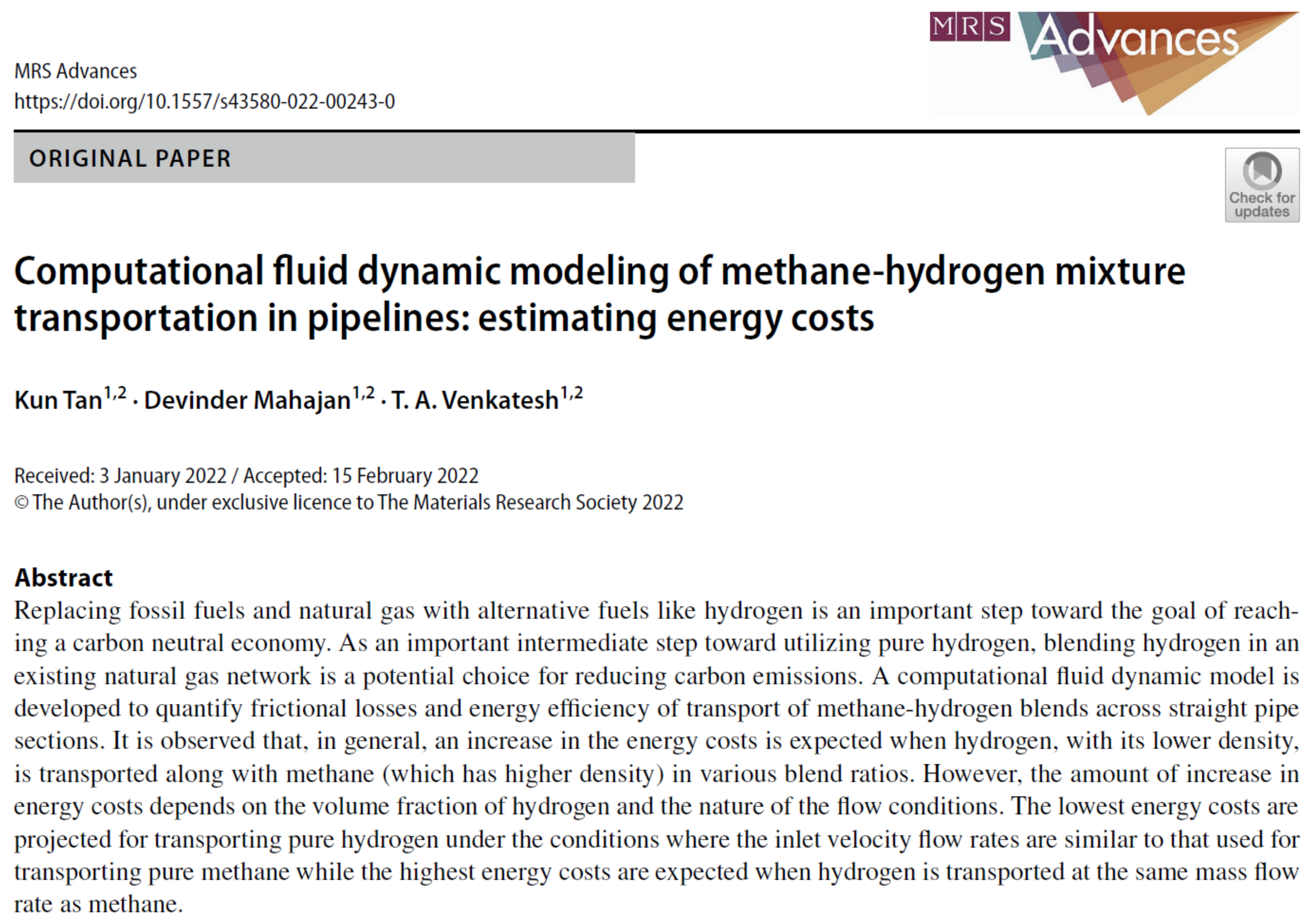
Abstract: Replacing fossil fuels with non-carbon fuels is an important step towards reaching the ultimate goal of carbon neutrality. Instead of moving directly from the current natural gas energy systems to pure hydrogen, an incremental blending of hydrogen with natural gas could provide a seamless transition and minimize disruptions in power and heating source distribution to the public. Academic institutions, industry, and governments globally, are supporting research, development and deployment of hydrogen blending projects such as HyDeploy, GRHYD, THyGA, HyBlend, and others which are all seeking to develop efficient pathways to meet the carbon reduction goal in coming decades. There is an understanding that successful commercialization of hydrogen blending requires both scientific advances and favorable techno-economic analysis. Ongoing studies are focused on understanding how the properties of methane-hydrogen mixtures such as density, viscosity, phase interactions, and energy densities impact large-scale transportation via pipeline networks and end-use applications such as in modified engines, oven burners, boilers, stoves, and fuel cells. The

NSF DMREF Project – Goals and Outcomes

Goals:
- Review hydrogen blending projects
- Conduct techno-economic analysis of blended gas flow in pipelines
- Advance fundamental knowledge of crack tip processes that control damage accumulation and propagation under fatigue loading

Outcomes:
- Framework for assessing energy costs for transporting blended gases
- Multi-scale model for hydrogen effects on fatigue evolution in ferritic steels
- Engineering roadmaps for life prediction and risk assessment for hydrogen storage and transport structures

Techno-Economic Analysis for CH4-H2 Blends



MRS Advances
https://doi.org/10.1557/s43580-022-00243-0

ORIGINAL PAPER

Computational fluid dynamic modeling of methane-hydrogen mixture transportation in pipelines: estimating energy costs

Kun Tan[1,2] · **Devinder Mahajan**[1,2] · **T. A. Venkatesh**[1,2]

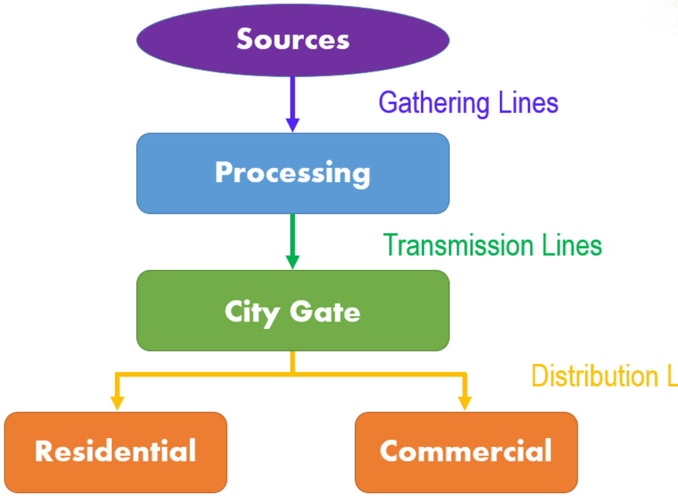
Received: 3 January 2022 / Accepted: 15 February 2022

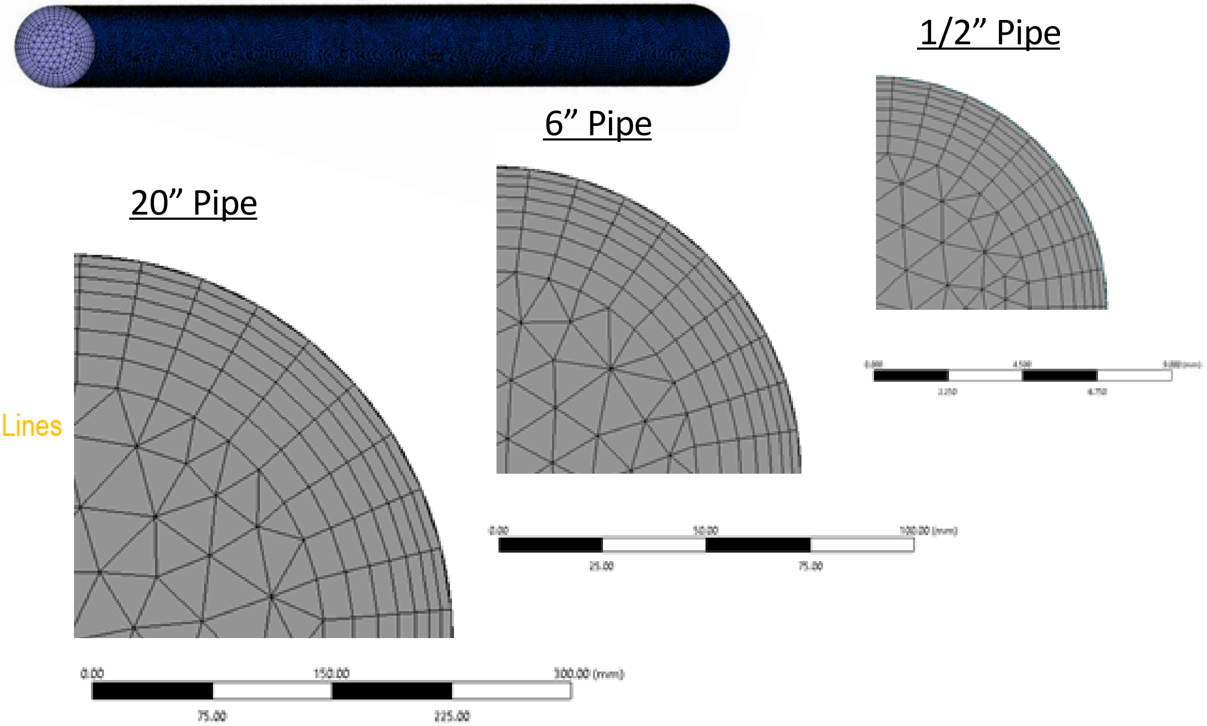
Abstract

Replacing fossil fuels and natural gas with alternative fuels like hydrogen is an important step toward the goal of reaching a carbon neutral economy. As an important intermediate step toward utilizing pure hydrogen, blending hydrogen in an existing natural gas network is a potential choice for reducing carbon emissions. A computational fluid dynamic model is developed to quantify frictional losses and energy efficiency of transport of methane-hydrogen blends across straight pipe sections. It is observed that, in general, an increase in the energy costs is expected when hydrogen, with its lower density, is transported along with methane (which has higher density) in various blend ratios. However, the amount of increase in energy costs depends on the volume fraction of hydrogen and the nature of the flow conditions. The lowest energy costs are projected for transporting pure hydrogen under the conditions where the inlet velocity flow rates are similar to that used for transporting pure methane while the highest energy costs are expected when hydrogen is transported at the same mass flow rate as methane.

CFD Model for the Flow of CH_4-H_2 Blends

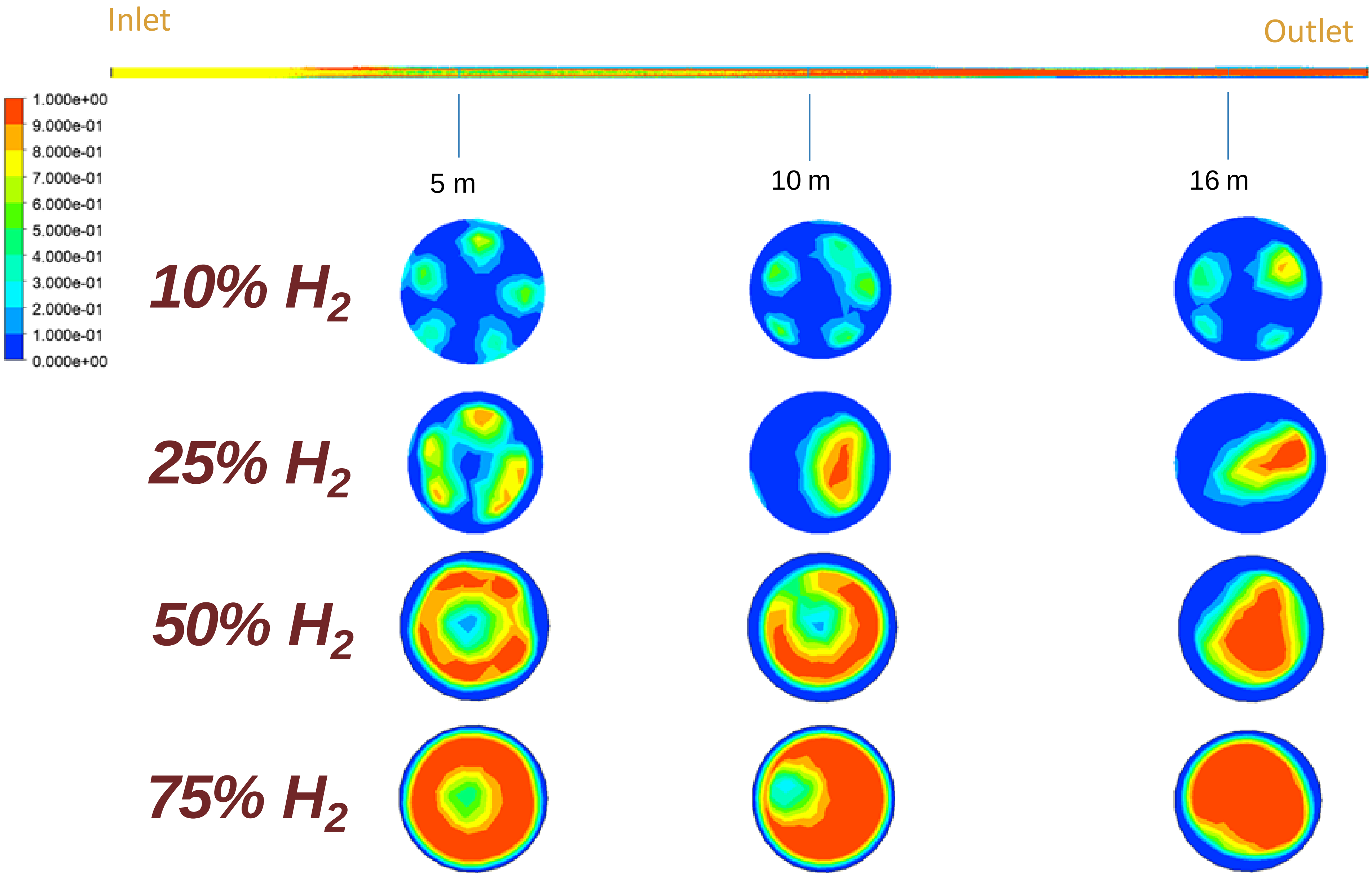
Materials	Pipe ID [1]	Element Size	# of Elements	Inflation Layers
Transmission	20” [1]	39 mm	484027	7
Distribution	6” [2]	12 mm	476965	7
Household	½” [3]	1.15 mm	487363	7





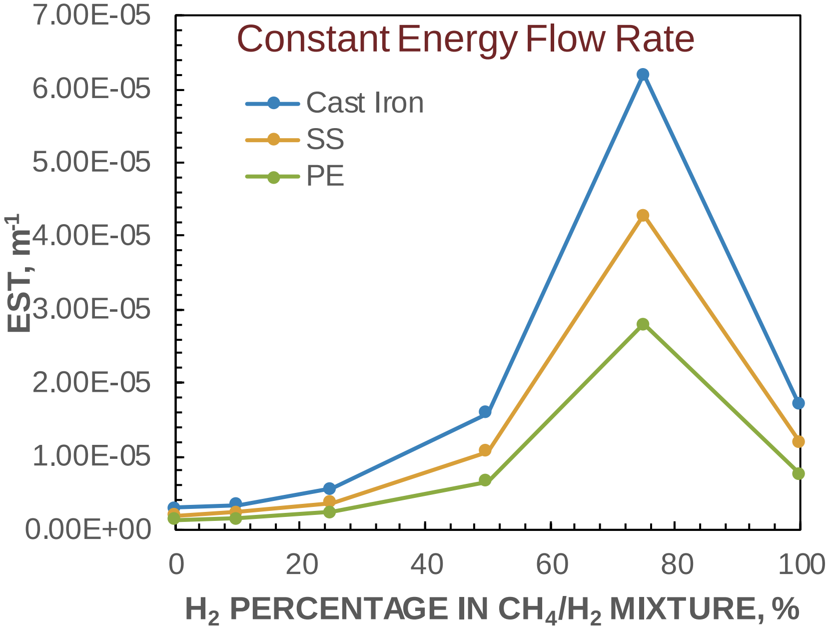
[1] http://naturalgas.org/naturalgas/transport/
[2] https://www.aga.org/natural-gas/delivery/how-does-the-natural-gas-delivery-system-work-/
[3] https://inspectapedia.com/plumbing/Gas_Pipe_Specifications.php

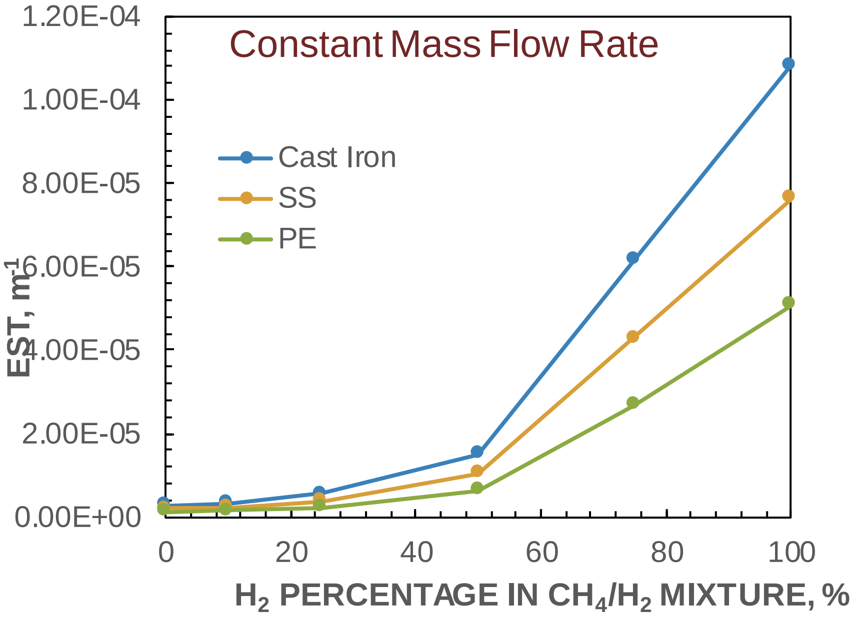
Flow Characteristics of CH4 – H2 Blends

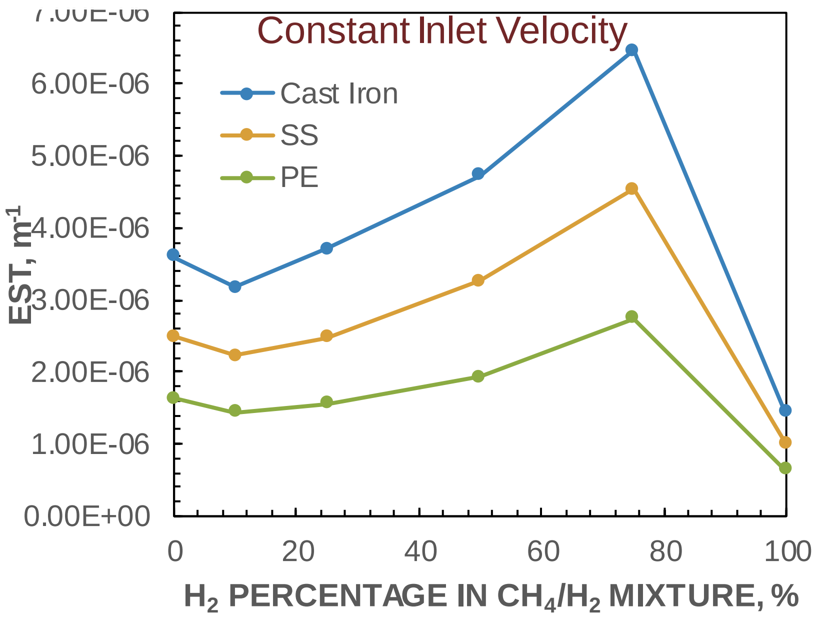


Energy Costs Due to Pipe Roughness

Materials	Surface Roughness
Cast Iron	259 um
Stainless Steel	50 um
Polyethylene (PE)	5 um







- Gas transportation in cast iron which has the highest surface roughness will incur the highest energy cost.

Metal Samples Inventory

9 7 8

2 14 4

3 4 15 1

Plastic Samples Inventory

5A 6A 7A 8A 9A 10A 11A 12A 13A

Samples Tested

Pipe samples characterization

Chemical ← → **Structural**

XPS, EDS

in-situ or ex-situ

EM, XRD, AFM

XPS-EDS Data- Sample #8

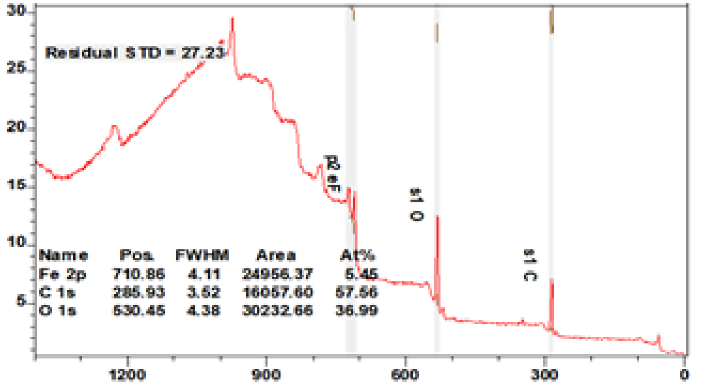
Pipe samples characterization

Chemical ← → **Structural**

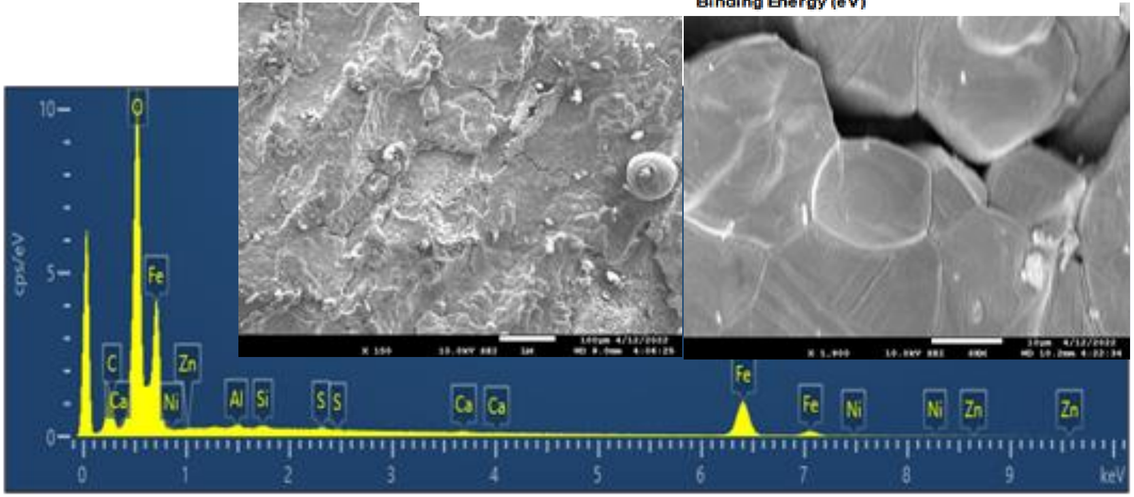
XPS, EDS

in-situ or ex-situ

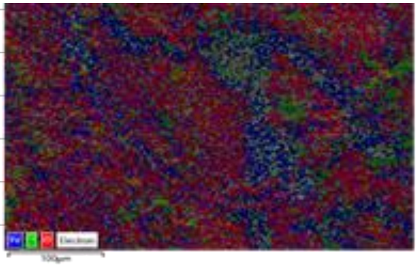
EM, XRD, AFM



Name	Pos.	FWHM	Area	At%
Fe 2p	710.86	4.11	24956.37	5.45
C 1s	285.93	3.52	16057.60	57.56
O 1s	530.45	4.38	30232.66	36.99

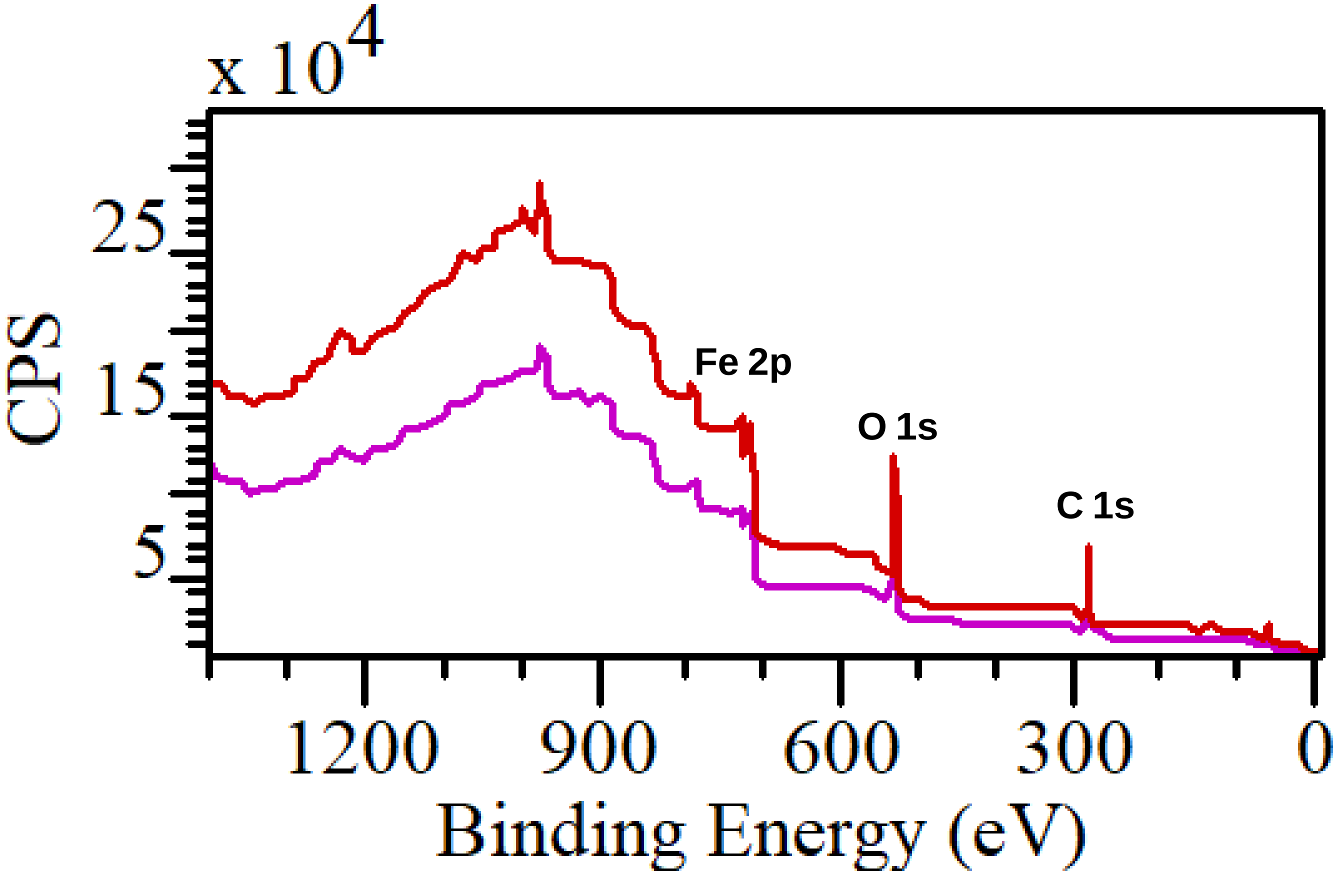


Element	Weight %
C	6.72
O	20.70
Fe	71.22
Others	1.36



XPS Data- Before and After H2 Exposure (#8)

XPS Survey – before and after 100 psi H_2



Before

After 100 psi H_2

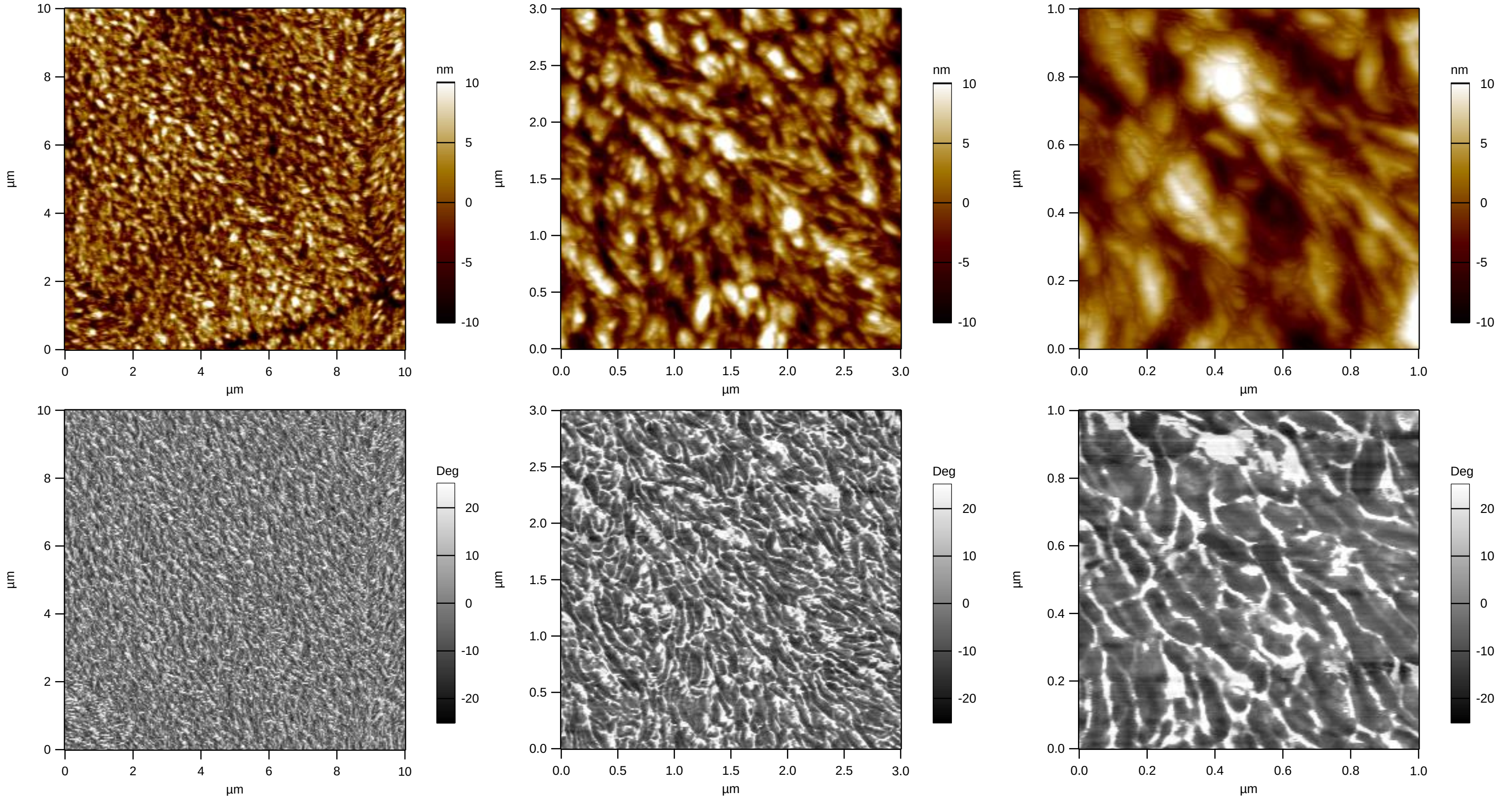
(2 weeks)

Atomic Force Microscopy Data for H2 exposed HDPE Samples

No significant changes in the surface crystalline morphologies with hydrogen exposure

Height

Phase



Large Scale H_2 Storage and On-Demand Production: Ammonia vs Methanol

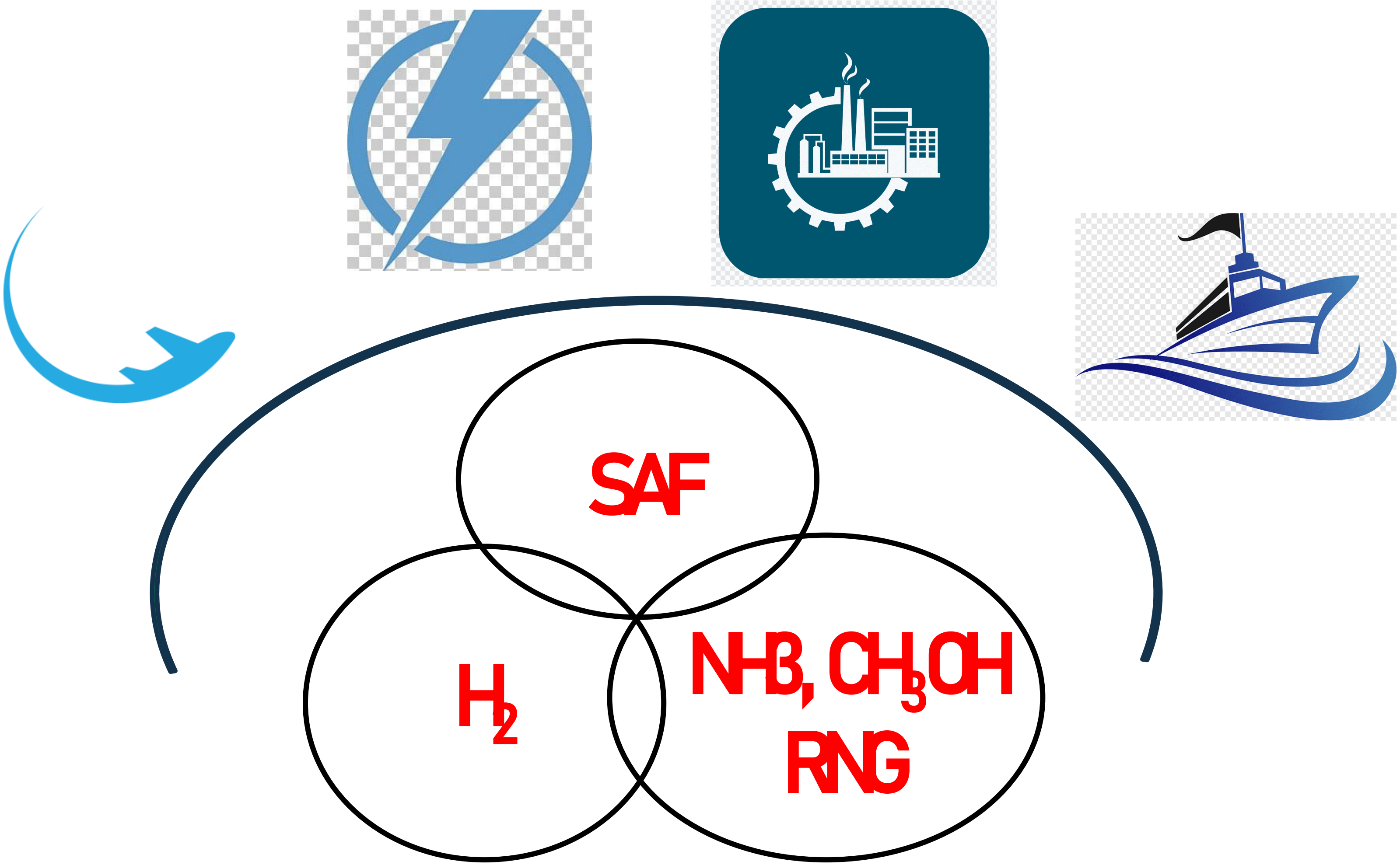
U.S. DOE H_2 Price Goals: \$2/Kg (2026); \$1 Kg (2031)

Parameter	Ammonia	Methanol
State	Liquid at -33.6 oC	Liquid up to +65oC
Safety	Pungent odor Toxic gas	Less toxic liquid
Energy Density, MJ/Kg	20.1	18.6
H_2 Storage Density	~18 wt%	18.75 wt% (with Reforming)
500 MWe Natural Gas fired plant	88,890 Kg NH_3	16,000 Kg H_2 = 85,333 Kg Methanol

Topics

- My Background
- The Need for Decarbonization
- Energy Storage– Need and Options
- Hydrogen Economy
- Energy Storage Application
- **Summary**

Net-Zero Fuels and Sectors Served



SAF

H_2

NH_3, CH_3OH
RNG

Ongoing R&D

Material Characterization: Materials that are resistant to H2 for long-term storage

Kinetics: To Understand heat management in H2 adsorption and Desorption.

System Integration: Integration of unit operations to implement Power-to-Products (P2X).

System Modeling.

- Test a system that combines solid absorbent (2 wt% H2 limit) with Methanol storage (18.75 wt%) for large scale applications.

Summary: SBU H2 Focus

U.S. DOE H2 Price Goals: $2/Kg (2026); $1 Kg (2031)

RD&D to IP	Workforce Training	Industry Collaboration
IP Generation– H2 Value Chain	DEI Training (OSWTI)	Pilot Projects 20+ Partners- (in the H2-Hub)

I-GIT Organized Events

P2X

- **Transatlantic Power-to-Gas {TAP2G) Workshop**, Aberdeen, Scotland [October 3-4, 2019]

Co-organizers: EMEC and I-GIT and Scottish Hydrogen and Fuel Association

- **Scale-Up Strategies to Monetize Power-to-Products (P2X).** December 9, 2020

Co-Organizers: I-GIT/RAPID/AIChE

- **Power2X Implementation Strategies Webinar.**

Co-Organizes: I-GIT and Food & Bio Cluster, Denmark. November 18, 2020

RNG

- **2nd Annual Scientific Summit on Dairy Methane Management Research**

Virtual 2020, December 3-4, 2020.

Co-Organizers: I-GIT/Cdfa/UC Davis/CSE/Denmark Trade Council

- **1st Annual Scientific Summit on Dairy Methane Management Research**

UC Davis, CA June 3-4, 2019. Co-Organizers: I-GIT/UC Davis/Cdfa/CSE/

- 3rd RNG Summit, December 13-14, 2021

Co-Organizers: I-GIT/Cdfa/UC Davis/CSE/Denmark Trade Council

Institute of
Gas Innovation
and Technology
AT STONY BROOK UNIVERSITY

Key Publications

1. Kun Tan, Devinder Mahajan, T. A. Venkatesh. Computational fluid dynamic modeling of methane-hydrogen mixture transportation in pipelines: estimating energy costs. **MRS Advances, 2022.** https://doi.org/10.1557/s43580-022-00243-0

2. Stephanie Taboada, Lori Clark, Jake Lindberg, David J Tonjes and Devinder Mahajan. Quantifying the Potential of Renewable Natural Gas to Support a Reformed Energy Landscape: Estimates for New York State. **Energies**. Published June 2021

3. Devinder Mahajan, Christopher Cavanagh, Arie Kaufman, Rong Zhao,, Shawn Jones, Gozde Ustuner, Jeff Hung. 2020 NY-BEST Energy Storage Technology and Innovation Conference. Mode: Virtual. **New York BEST**. Session: Topic: New Developments in Non-Battery Energy Storage Technology. Session: “Super long duration storage: Hydrogen and Power-to-gas. December 8-9, 2020.

4. Devinder Mahajan, Stephanie Taboada, Lori Clark, and Kyoung Ro. Estimation of renewable natural gas potential in New York State. PRESENTATION FORMAT: On-Demand Oral. DIVISION/COMMITTEE: Environmental Chemistry. **2020 Fall ACS Meeting**. San Francisco, CA. PAPER ID: 3434346.

5. Stephanie Taboada, Devinder Mahajan, Christopher A. Cavanagh, McKenzie Schwartz. *Hydrogen injection in natural gas pipelines for decarbonization of power sector in New York State*. Symposium: Fuel Processing for Hydrogen Production, Transforming the Future through Chemical Engineering. **AIChE Annual Meeting 2019**. Hyatt Regency, Orlando, Orlando FL, United States. November 10-15, 2019. AIChE Abstract ID# 579106.

I-GIT In The News

PRESS RELEASES

- Hydrogen Blending Research for a Net Zero Future. https://www.nationalgrid.com/us/cop26/hydrogen-vision/stony-brook-case-study
- "The Hydrogen Race": American Gas Magazine, April 2021 issue. https://read.nxtbook.com/aga/american_gas_magazine/american_gas_april_2021/american_gas_april_2021.html
- Hydrogen Heats up in New York, March 17, 2021. https://www.politico.com/states/new-york/albany/story/2021/03/17/hydrogen-heats-up-in-new-york-1368604
- National Grid sees hydrogen as a lynchpin, joins utilities **targeting net zero carbon by 2050 | Utility Dive.** https://www.utilitydive.com/news/with-hydrogen-as-lynchpin-strategy-national-grid-joins-other-utilities-i/586386/
- **Natural Gas Goes to College. AGA Magazine– August/September 2019 issue.** https://read.nxtbook.com/aga/american_gas_magazine/american_gas_aug_sept_2019/natural_gas_goes_to_colege.html

I-GIT In The News

$1.8M NSF Grant Helps SBU Team Explore Clean Energy Alternatives with Hydrogen. September 27, 2021

https://news.stonybrook.edu/university/1-8m-nsf-grant-helps-sbu-team-explore-clean-energy-alternatives-with-hydrogen/?spotlight=6

From Ideas to Startups: Advice from Successful SBU Faculty Entrepreneurs

https://www.stonybrook.edu/commcms/technology-licensing/news/From-Ideas-to-Startups.php.
October 14, 2021

Reognition

Advanced Energy Conference: AEC 2021 [Virtual mode], June 9-10, 2021
4 posters submitted. H2 Blending poster won an award in the Undergraduate category
https://aec2021.aertc.org/posters/results/