Pacific NorthWest Economic Region

The Pacific Northwest Economic Region Presents:

INNOVATIVE ENERGY SOLUTIONS

Tuesday, August 16th | 10:45am-11:45am

Photo Courtesy of Montana Office of Tourism & Business Development

THANK YOU TO OUR SESSION SPONSOR

Capital Power Corporation

Opening Remarks from:

Rick Glumac
MLA, Government of British Columbia

Ron Ballman
CEO
Adventech

Moderated by:

Jason Thackston
Sr. Vice President, Energy Resources
Avista

Panelists:

Kate Chisholm
SVP, Planning, Stakeholder Relations, & Chief Sustainability Officer
Capital Power

Anna Stukas
VP of Business Development
Carbon Engineering

Richard Boardman
Laboratory Relationship Mgr., Fuel Cell and Hydrogen Technology Office,
Idaho National Lab

Photo Courtesy of Montana Office of Tourism & Business Development

Avista's Cleaner Energy Future:
Solutions Beyond Wind and Solar

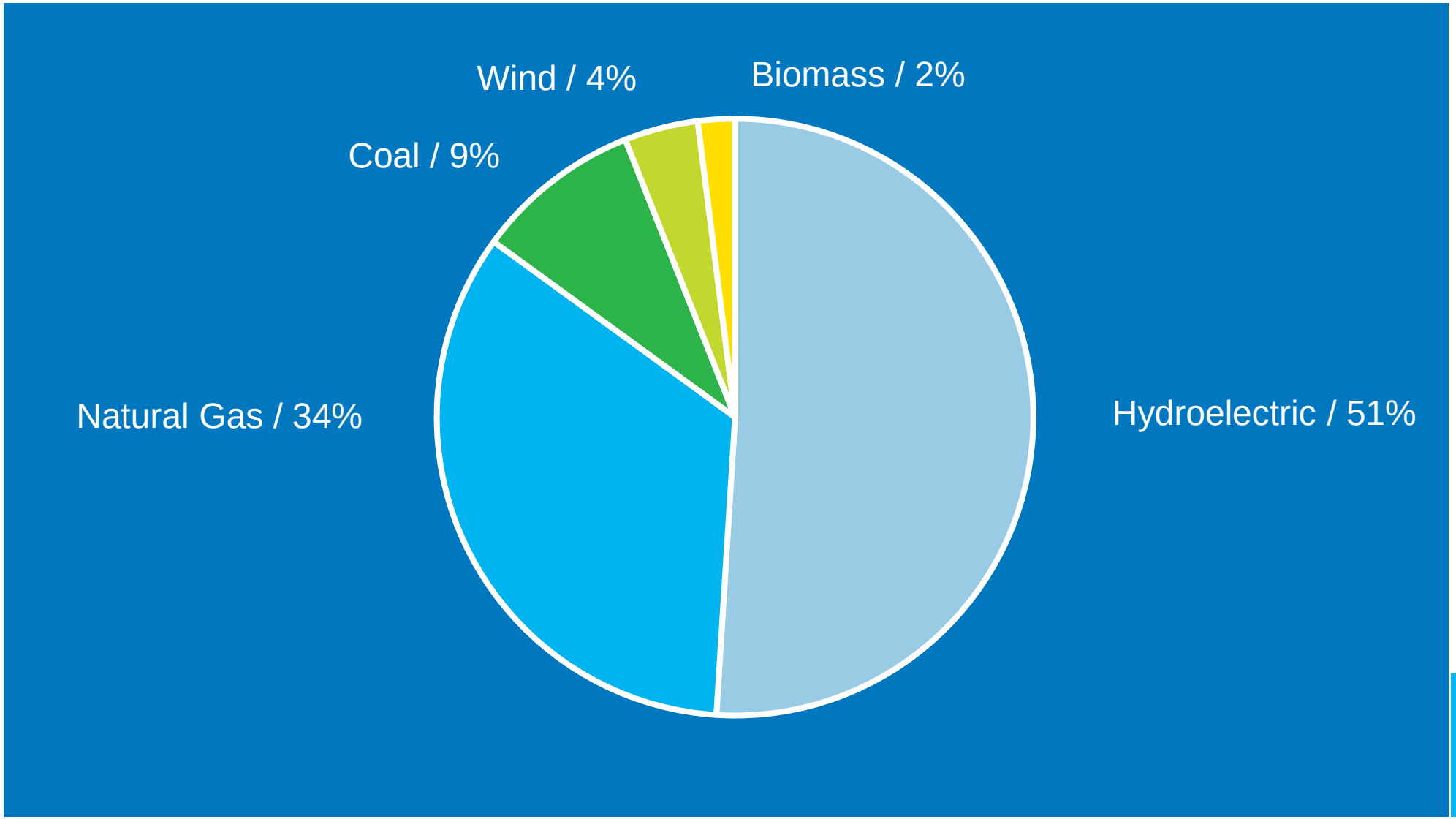
Jason Thackston, Senior Vice President, Energy Resources

August 17, 2021

About Avista

Avista Electric and Natural Gas Service Areas

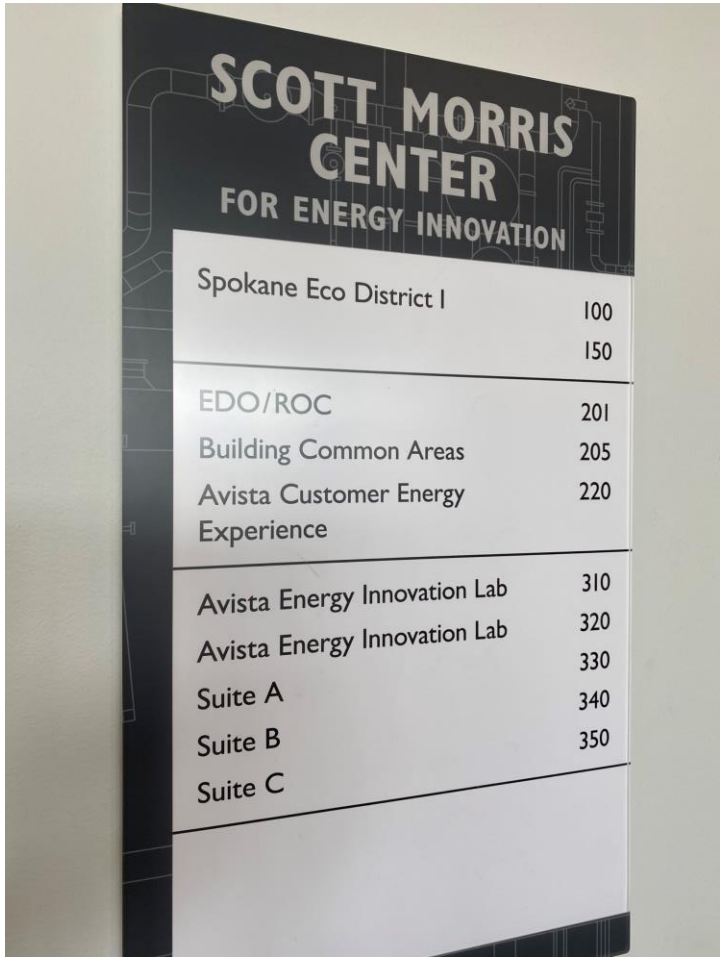
Our Current Generation Mix



Avista's Clean Electric Goals

- Avista's goal is to serve our customers with **100 percent clean electricity by 2045** and to have a **carbon-neutral** supply of electricity by the end of **2027**
- We will maintain focus on **reliability** and **affordability**
- **Natural gas** is an important part of a clean energy future
- **Technologies and associated costs** need to emerge and mature in order for us to achieve our stated goals
- It's **not** just about generation

Avista's Morris Center



Avista's Morris Center

Power & Control Hardware in the Loop

Partner Space for Innovation

Data Platform for Operational Platform

Avista's Innovation Lab

Eco-District Energy Plant

Dispatchable/Flexible Load

WSU Shared Energy

Microgrid – Grid resiliency

Distributed Energy Resources

Inverter Based Power Production

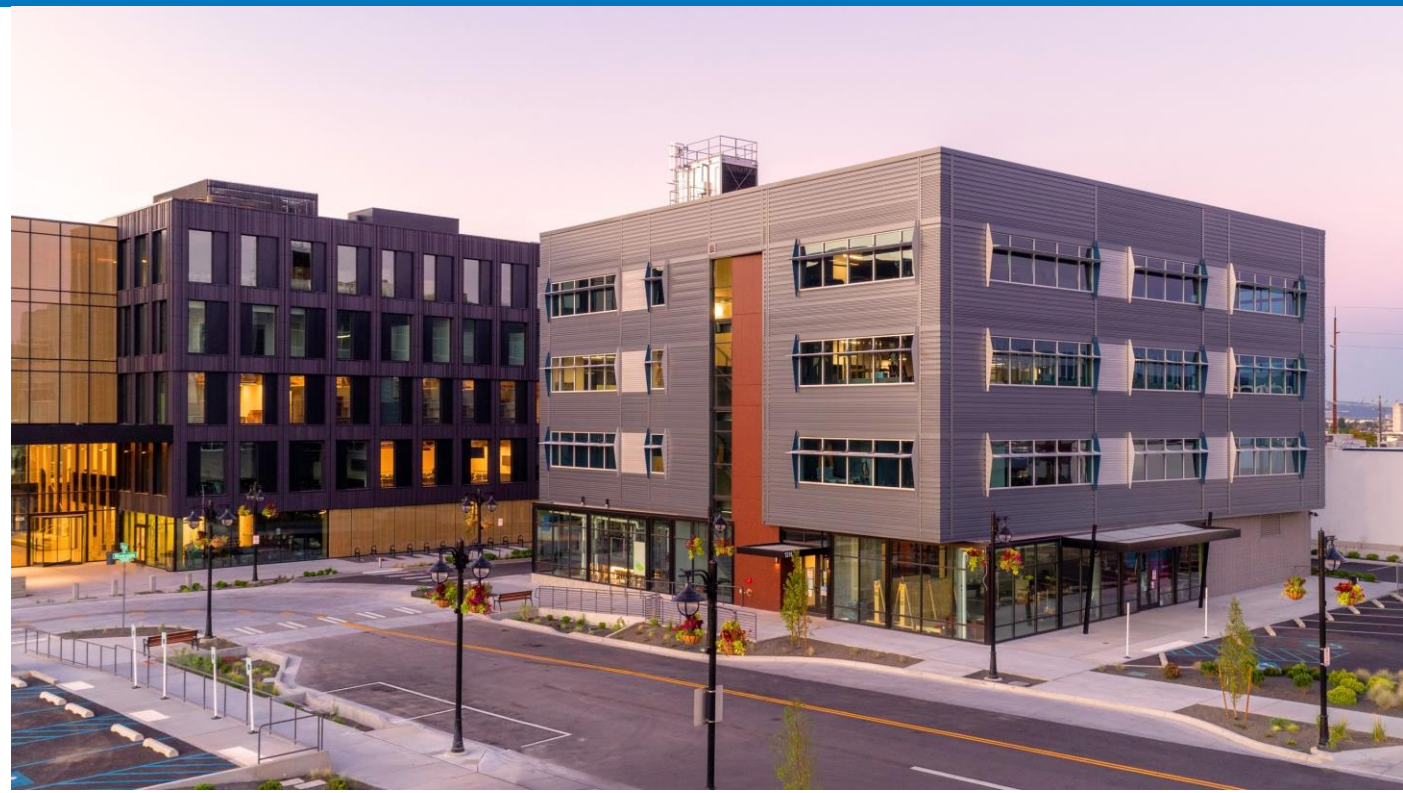
The Role of Hydrogen and Renewably Generated E-Fuels

- Blended in with traditional natural gas to **reliably generate power** and **supply fuel** to natural gas customers with a cleaner carbon footprint

- Combine with renewable energy to **produce hydrogen** when grid has surplus electricity

Serving our Customers into the Future

- Additional clean generation
- Dispatchable generation or renewables + storage
- Ongoing energy efficiency programs
- New ways to partner with customers
- Electric transportation



Avista's Cleaner Energy Future:
Solutions Beyond Wind and Solar

Jason Thackston, Senior Vice President, Energy Resources

August 17, 2021

Decarbonization & CCUS

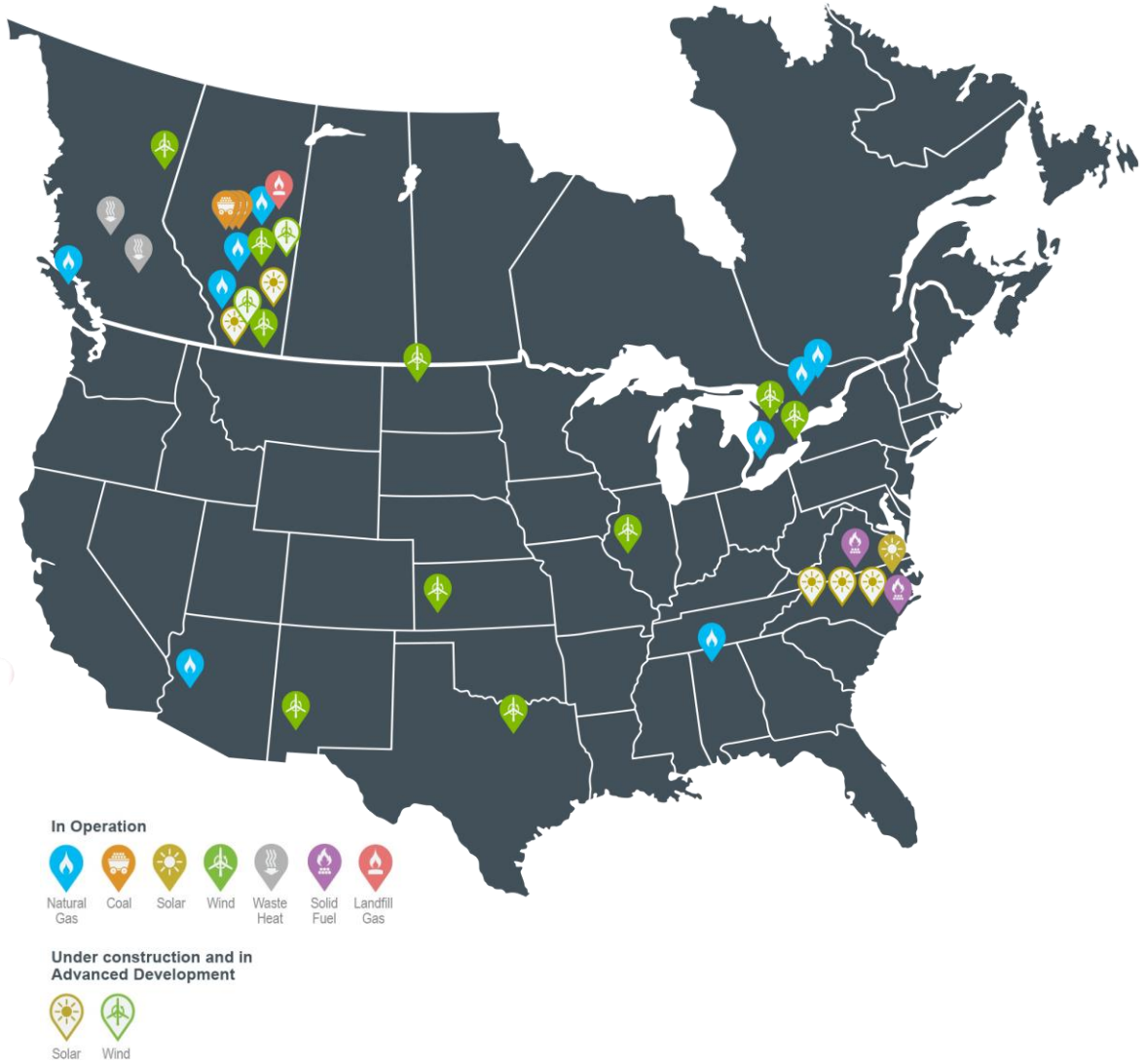
Presentation to PNWER Annual Summit
Kate Chisholm, Senior Vice President & Chief Sustainability Officer
August, 2021

Capital Power

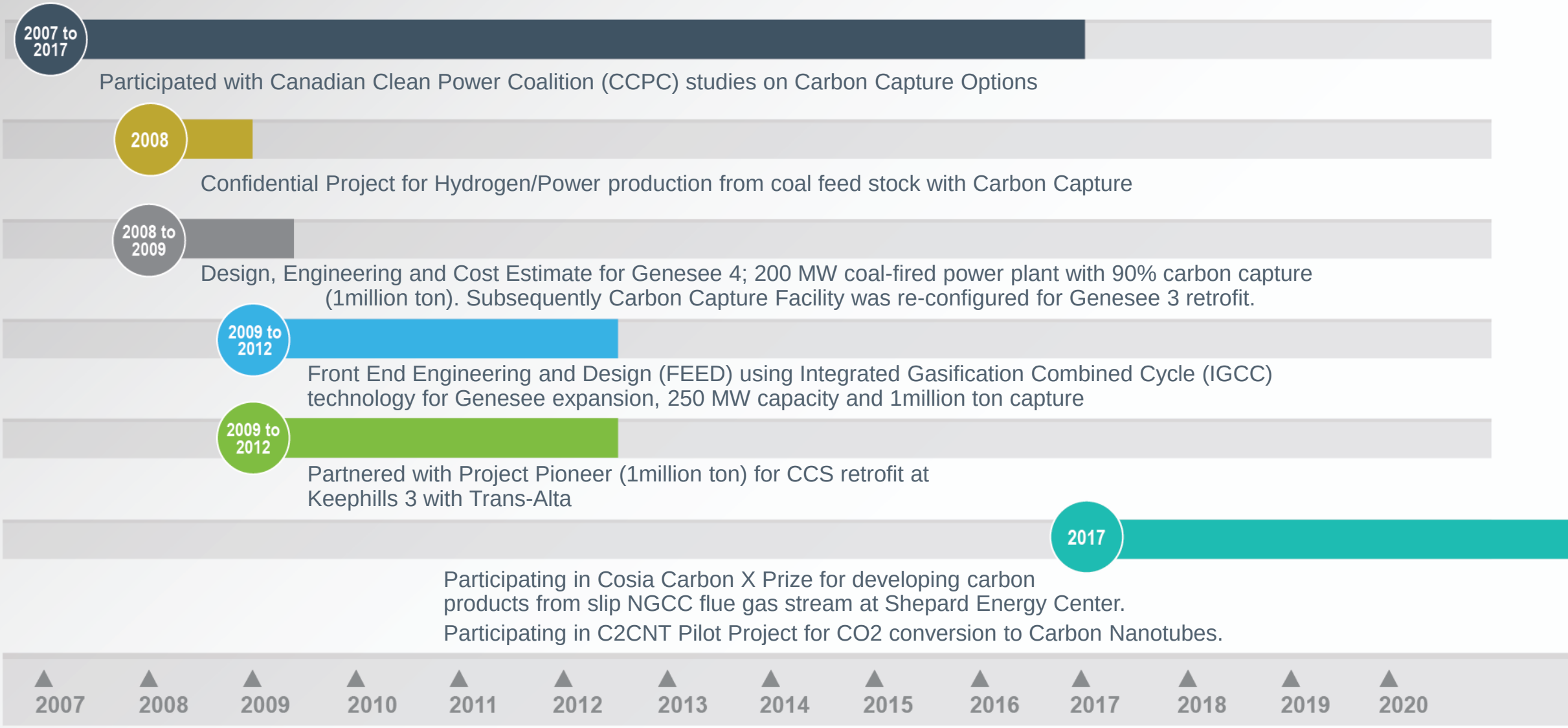
RESPONSIBLE ENERGY
FOR TOMORROW

Growth-oriented North American Power Producer

- Publicly-traded company headquartered in Edmonton, Alberta with a market cap of ~$3.8B
- Owns ~6,500 megawatts of power generation capacity at 28 facilities in Canada and the U.S. Additional 985 MW in advanced development in Alberta and North Carolina.
- A leading developer of carbon offset projects, with more than $100M invested
- Named one of the World's Most Ethical Companies® by the Ethisphere Institute (2019, 2020, 2021)
- Recognized by Capital Finance International as Best ESG-Responsible Energy Producer (Canada) 2020
- Named one of "Alberta's Top Employers" for six years in a row



Capital Power major carbon capture initiatives



Capital Power's Path to Net Carbon Neutral by 2050

- Genesee efficiency program,12% decrease in GHG by 2021
- Over $3B invested in/committed to renewables
- C2CNT interest increased to 40%
- Over $40M invested in carbon capture research
- Completed two CCUS FEED studies (2007/2011)

- Complete repowering and off coal
- Invest in renewables, strategic natural gas
- CCU: C2CNT & Beyond
- Invest in renewables + storage project
- CCUS FEED study at Genesee
- Assess hydrogen at Genesee
- Explore commercial / physical Direct Air Capture (DAC) solutions

- Expand CCU
- Develop CCUS and/or hydrogen application at Genesee.
- Add DAC to carbon compliance portfolio

- Net carbon neutral via physical solutions on natural gas assets, DAC and "offsets"
- Invest in DAC facility
- Renewables + storage as baseload

- Physical decarbonization

Decarbonization in action

Reducing CO_2 emissions by ~3.4 million tonnes per year

Over **$1 billion** invested

Genesee 1 & 2:

- Repowering to best-in-class NGCC technology
- CCS ready and hydrogen capable

Genesee 3:

- Coal-to-gas conversion
- Building the *Genesee Carbon Conversion Centre (GC^3)* to transform emissions into carbon nanotubes (CNTs)

Why GC³

- Environmentally Friendly
  - CCU process that captures CO_2 from flue gas and converts into a usable product
  - Facility to utilize C2CNT technology – an NRG COSIA Carbon XPRIZE finalist and X-Factor award winner
- Creates a product that can be used across all industries
  - Chemical & Polymers, Energy, Aerospace & Defense, Electronics, Batteries & Capacitors, Medical, Advanced Materials, **Structural Materials**
- Pathway to achieving net-zero emissions
  - Material emissions reductions in heavy industrial processes
- Largest commercial-scale carbon nanotube production facility globally
  - Opportunity to become primary supplier of CNTs to North America – Asia current world leader in CNT production (top 5 facilities = 400-700t/year)

Genesee CCUS Project Overview

3 MT per year of carbon capture by 2026 will materially advance decarbonization of Alberta's electricity grid while preserving system reliability and competitiveness

- Project would deploy the latest post combustion carbon capture technology on the soon to be repowered GN 1&2.
- The Project would capture 90% of the carbon emitted from GN 1&2; approximately 3M tonnes per year.
- The Project leverages Capital Power's 10+ years of experience in CCUS.
- The Project is aligned with Capital Power's 2030 and 2050 Sustainability Targets.
- Shovel in the ground Q1'24.
- First tonne of carbon in the ground Q3'26.

- Complete Q4'21
- Complete Q4'22
- Q1'24 Start
- H2'26

Momentum for Carbon Conversion, CCUS

- Significant increase recently in recognition by governments in Canada and U.S. of role of CCUS in achieving long-term decarbonization objectives.
- In US, Senate just passed Bipartisan Infrastructure legislation including *SCALE Act* in its entirety to help finance the buildout of CO_2 transport and storage infrastructure.
- In Canada, importance of CCUS acknowledged in Federal Government December 2020 Climate Plan Update, and in related "Net-Zero Pathways" report released by Canadian Institute for Climate Choices.
- Alberta and Federal government CCUS Working Group to "explore opportunities with (CCUS) technology, and how Alberta can lead the way in setting up Canada to be a global leader in emissions-reducing technology."
- Federal Government commitment in Budget 2021 to develop Investment Tax Credit to support accelerated deployment of CCUS, and continue funding for CCUS R&D.
- Alberta Government undertaking competitive "CCUS Hub" process to develop transportation and sequestration components of CCUS infrastructure
- CCUS identified as an area for enhanced collaboration as part of June 2021 Canada/US MOU Concerning Cooperation on Energy

Enabling Policy Framework

Resolution of current policy initiatives can provide certainty to support long-term investment decisions

Alberta CCUS Hub

- Competitive process execution timelines need to facilitate pre-2030 capture projects
- Evaluation criteria need to prioritize connection to projects with earliest in-service dates
- Multiple hubs would facilitate proximity and reasonable costs for capture regions
- Capture facilities most capital-intensive and cost challenged component of CCUS chain

CCUS ITC

- A “direct pay” option that provides value of credit immediately is essential to value of program to investors and to pace of CCUS deployment across all industry sectors
- A direct pay approach is “bankable” for investors and enables lower-cost financing
- Direct pay would align with key enhancement being pursued with U.S. 45Q

Carbon Policy & Markets

- Project economics reflect carbon price escalation to $170/t by 2030, and compliance costs and EPC value relative to current Alberta TIER stringency of 0.37 t//MWh.
- Potential for policy changes that affect core assumptions, including carbon market structure, creates significant investment risk and raises required investment returns
- Commercial agreements between governments and proponents to keep proponents whole in event of carbon policy-related changes would address “policy gap.”

Capital Power

RESPONSIBLE ENERGY
FOR TOMORROW

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Carbon Engineering

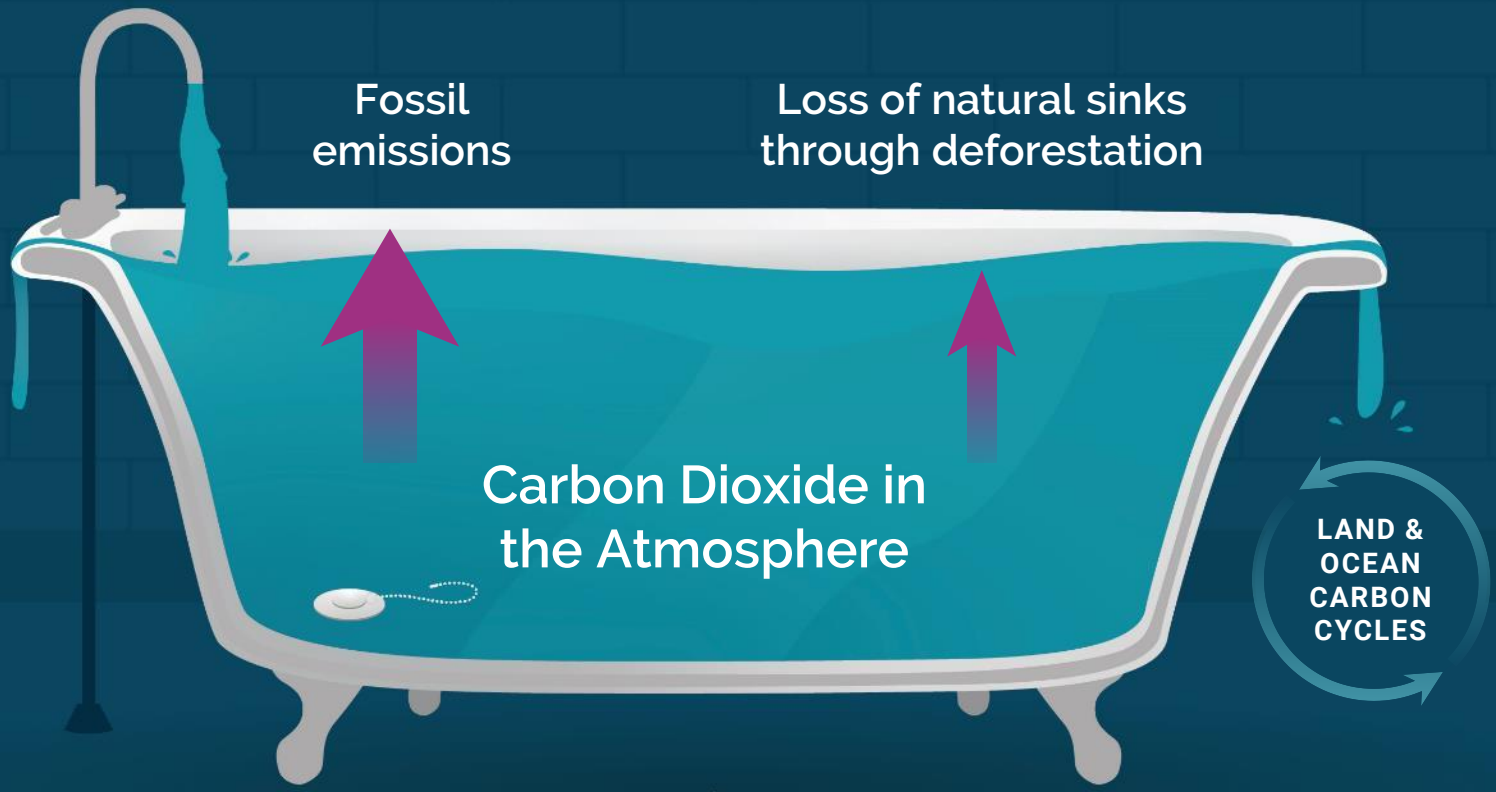
The Climate Revolution

AND HOW DIRECT AIR CAPTURE WILL ENABLE CLEAN INFRASTRUCTURE, MITIGATE RISK, AND PROVIDE AFFORDABLE NET-ZERO SOLUTIONS

AUGUST, 2021
PNWER Annual Summit

Anna Stukas, P.Eng
VP Business Development
Carbon Engineering

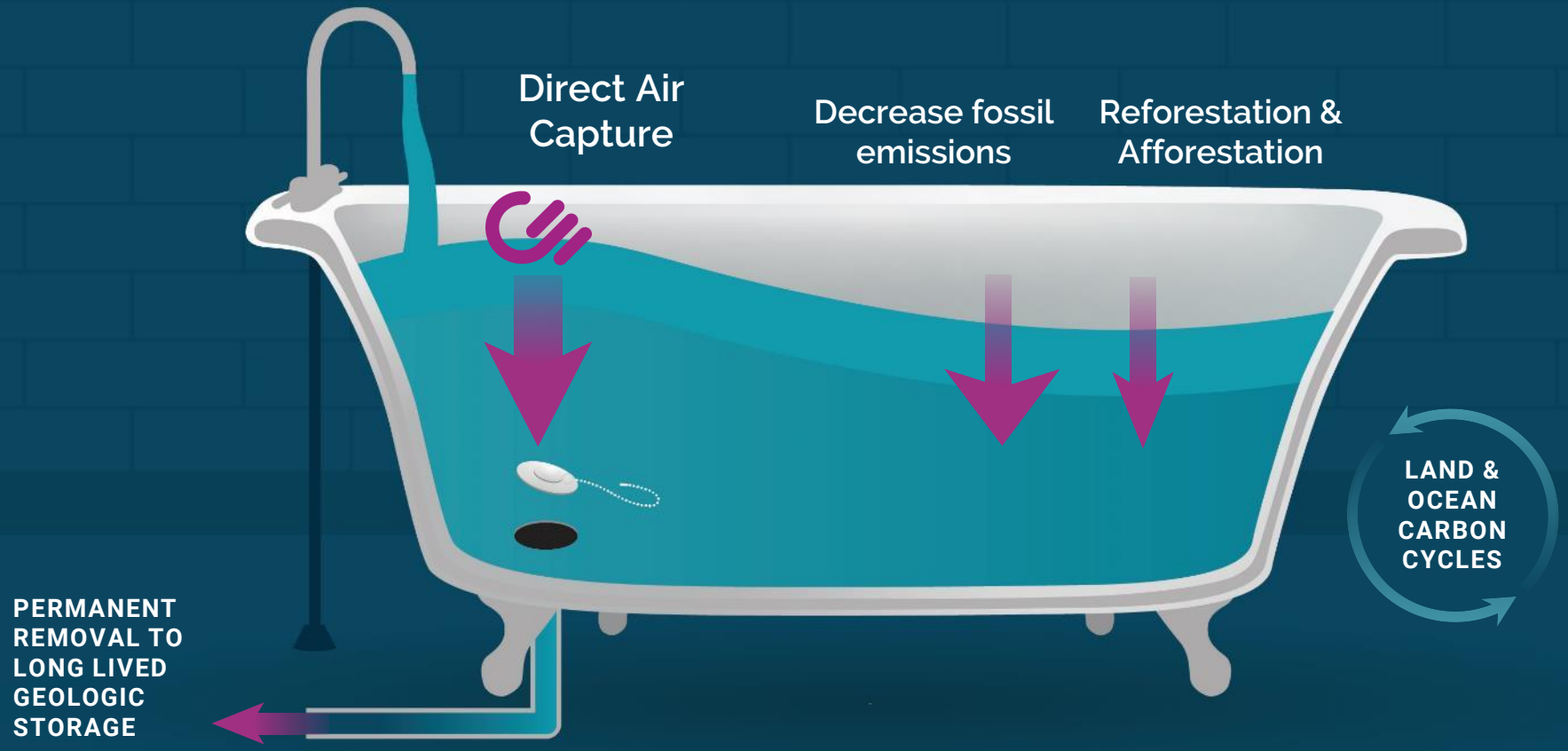
Our climate bathtub is about to overflow



THE VOLUME OF CO_2 IN THE ATMOSPHERE DRIVES CLIMATE IMPACT

We Need a Variety of Tools to Reduce this CO_2 Volume

Permanent CO_2 removal is essential alongside fossil emissions reduction and reversing deforestation

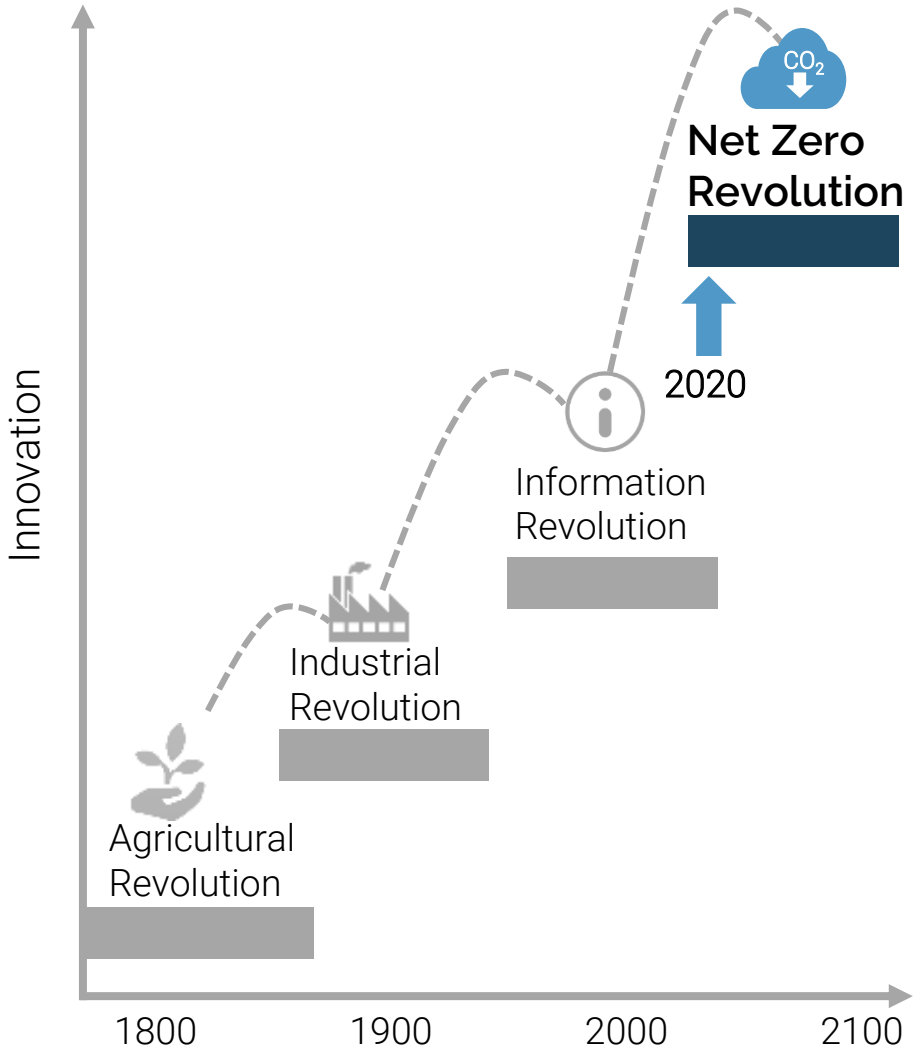


REDUCE existing emissions → **30-40 BILLION TONS/YR**

REMOVE equivalent for all remaining emissions → **10 -15 BILLION TONS/YR**

REMOVE legacy emissions for climate restoration → **ADDITIONAL 10-20 BILLION TONS/YR**

The Net Zero revolution has started



John Kerry
US Special Presidential Envoy for Climate

There is a huge new market opening up. I think its very exciting and, in my judgement, its going to be the biggest market we've seen in the world since the industrial revolution.

"Even if we get to net zero, we still have to get carbon dioxide out of the atmosphere

"About half the emissions we have to reduce are going to be reduced by technologies that are not yet at scale in the market." [1]

Mark Carney
UN Special Envoy on Climate Action and Finance

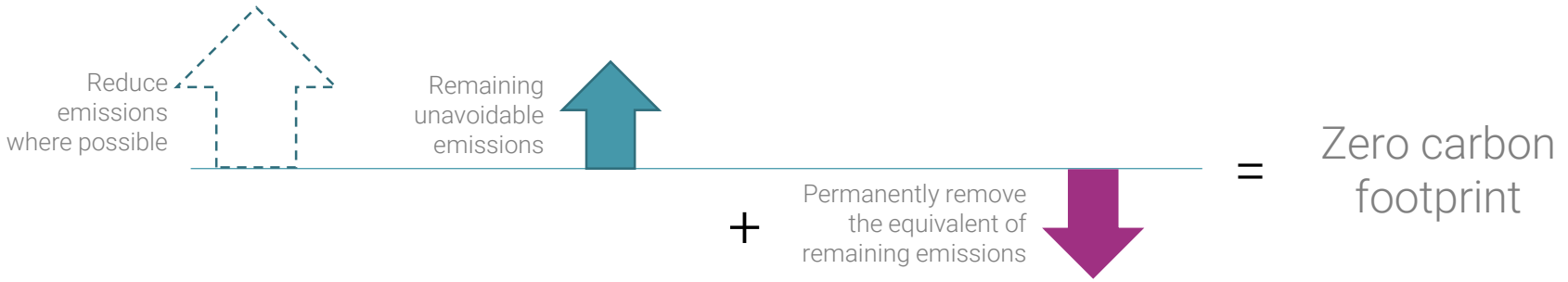
Transition to net zero emissions is 'the greatest commercial opportunity of our age"[2]

1. John Kerry speaking at President Biden's Leaders Summit on Climate, 2021/4/21
2. Mark Carney, speaking at the Green Horizon Summit. 2020/11

DO WE HAVE SOLUTIONS THAT COMBINE THE NEED FOR ACTION WITH ECONOMIC REALITY?

What Does This Mean?

- Companies and governments will have to achieve net zero, operating with no net addition of CO_2 to the atmosphere ("a zero carbon footprint")
  - Catalyst may be shareholders, customers or government regulation



- The cost of achieving net-zero will be significant and, for some, will threaten future viability
- Carbon footprints will be able to be reduced initially with modest financial impact, however the complexity and impact will grow over time
- The cost of compliance will start to feature as a key contingent liability on public accounts

The Technological Missing Piece

Only one solution is available today that addresses the three key problems

1. **COST**
   Is affordable compared to alternatives for many emissions
2. **GROWTH IN EMISSIONS**
   "Has the potential to be almost infinitely scalable" [1]
3. **NON-DISRUPTIVE**
   Eliminates any emission or any type from anywhere and from any point in time, for a fixed cost

CE's Innovation Centre in British Columbia, Canada

CE's first large-scale plant in the US will go operational by 2025 and capture up to one million tonnes of atmospheric CO_2 per year

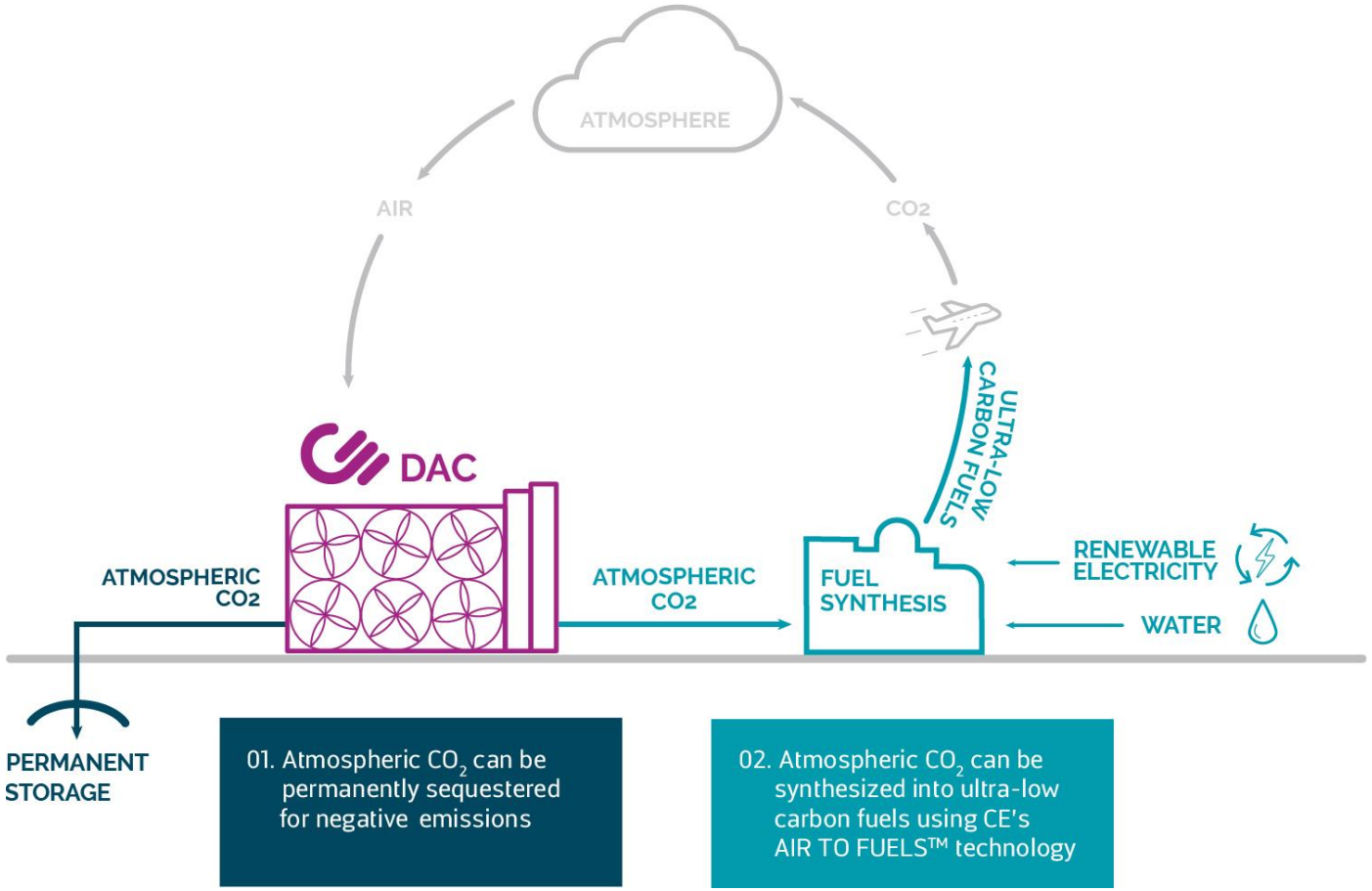
[1] Goldman Sachs – Carbonomics: The Future of Energy in the Age of Climate Change.

PROVEN TECHNOLOGY NOW DEPLOYING AT COMMERCIAL SCALE

Carbon Engineering Brings Solutions at Climate-Relevant Scale

Direct Air Capture (DAC) & AIR TO FUELS™ technologies deliver:

- **Permanent, climate-relevant volumes[1] of carbon dioxide removal** by capturing CO_2 from the atmosphere and safely sequestering it in the geosphere or durable carbon products
- **Drop-in compatible synthetic fuels** that reduce the carbon intensity of transportation fuels by recycling atmospheric carbon



[1] Each standard, commercial CE DAC plant removes one million tonnes of atmospheric CO_2 per year, the equivalent of the work of 40 million trees.

ELIMINATION OF ANY EMISSION, OF ANY TYPE, FROM ANYWHERE AND ANY TIME

AIR TO FUELS™ Products

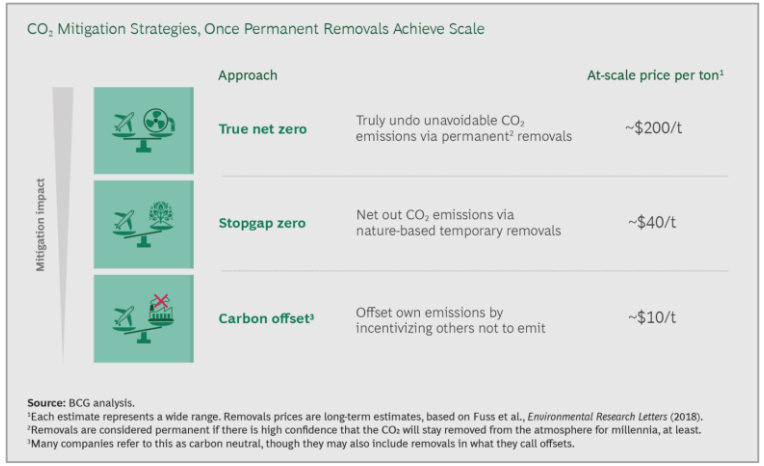
- Use of captured atmospheric CO_2 and renewable electricity produces a near carbon neutral fuel
- Refined into diesel, jet fuel or gasoline
- No conflict with other feedstock needs
- No sulfur, very low particulate matter and aromatic hydrocarbons
- Wholly compatible with all existing vehicles, ships and airplanes without modification

LOW CARBON, CLEAN BURNING

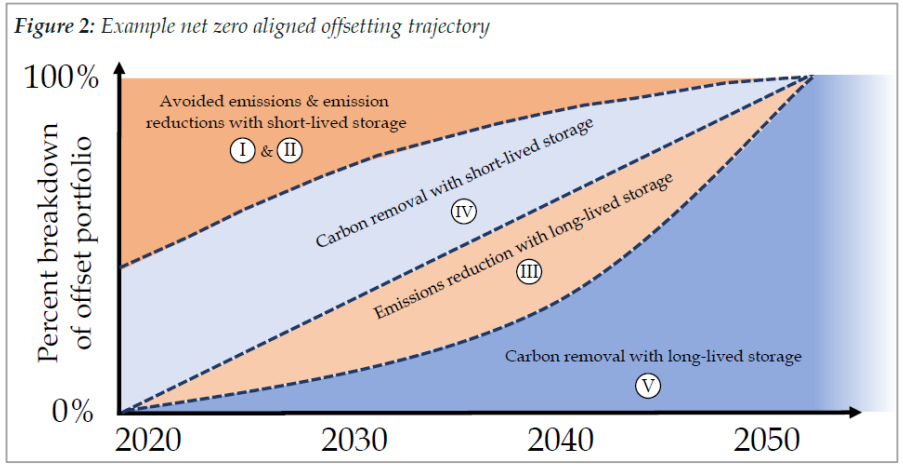
CE's fuel (right) compared to conventional diesel (left)

Why Permanent Carbon Removal?

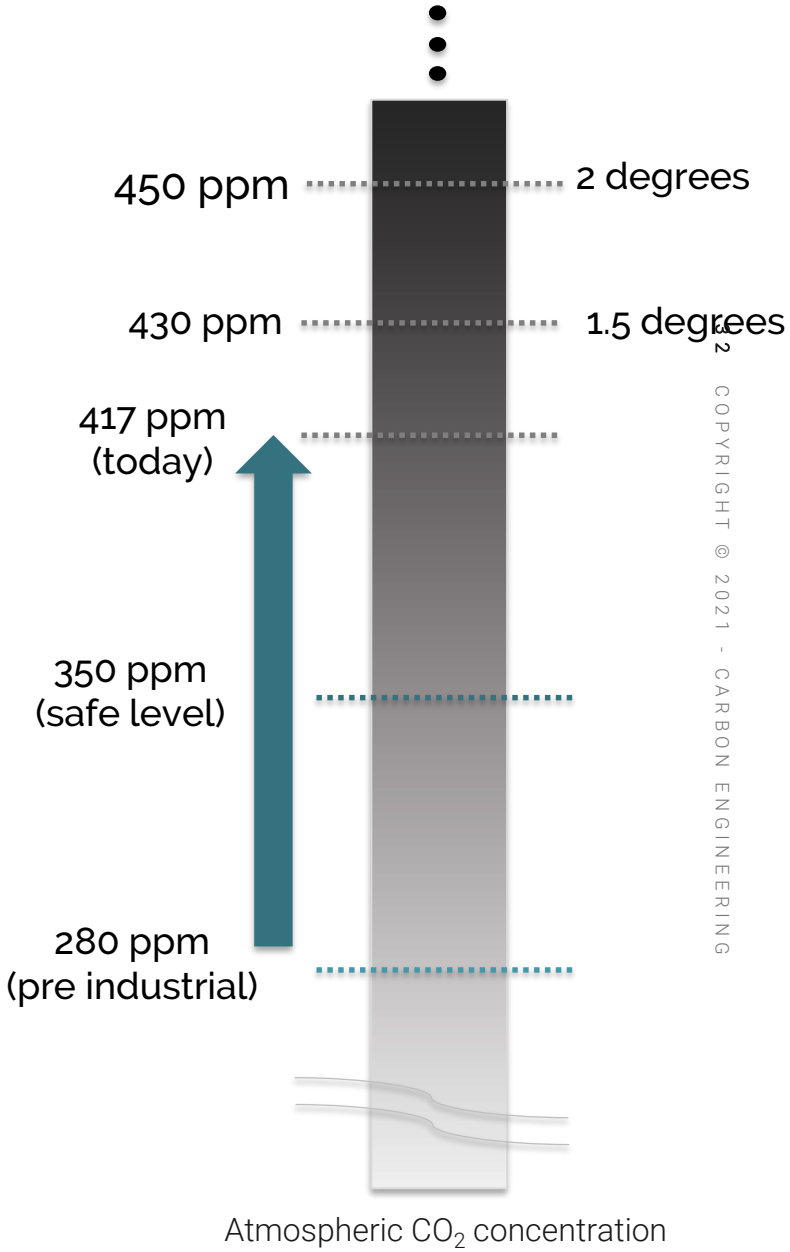
- In the past ~200 years, through the extraction and combustion of fossil fuels, the world has shifted over 1 trillion tonnes of CO_2 from underground (in the geosphere) up into the active biosphere (air, land, oceans), increasing the concentration of CO_2 in the atmosphere
- Per climate experts around the world, and as highlighted by BCG and Oxford University below, we must reduce emissions where we can and then shift as quickly as we can to permanent carbon removal to offset unavoidable emissions
- Nature-based carbon storage is an important "stopgap"[1] measure as we deploy permanent carbon removal solutions, but biological sinks are only temporary and indeed, can become sources as the world warms up



We Need True Net Zero, and It Needs Early Adopters [1] BCG



The Oxford Principles for Net Zero Aligned Carbon Offsetting, Oxford University

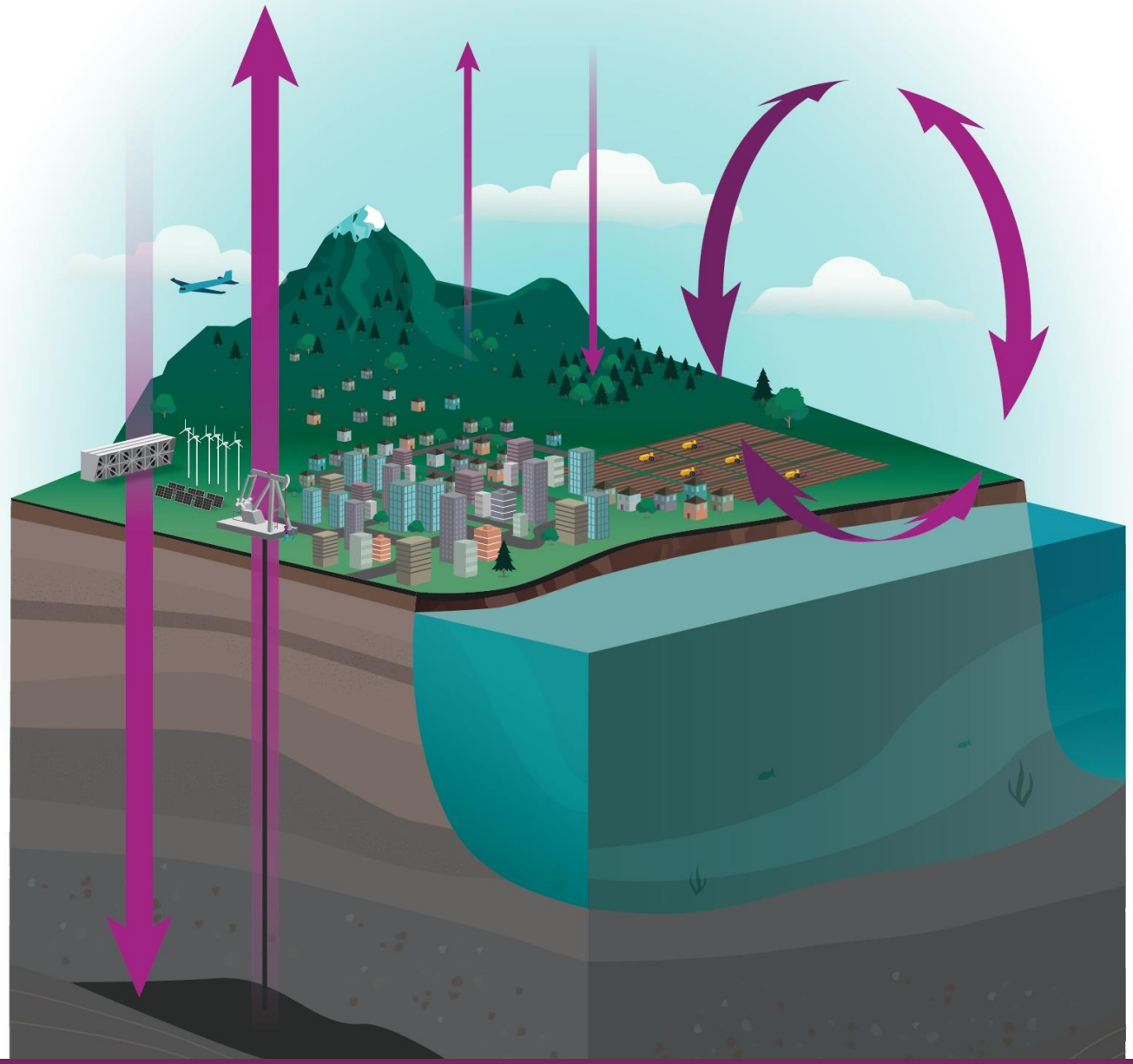


Atmospheric CO_2 concentration

WE MUST "TRULY UNDO UNAVOIDABLE CO_2 EMISSIONS VIA PERMANENT REMOVALS" [1]

Restoring the Carbon Balance

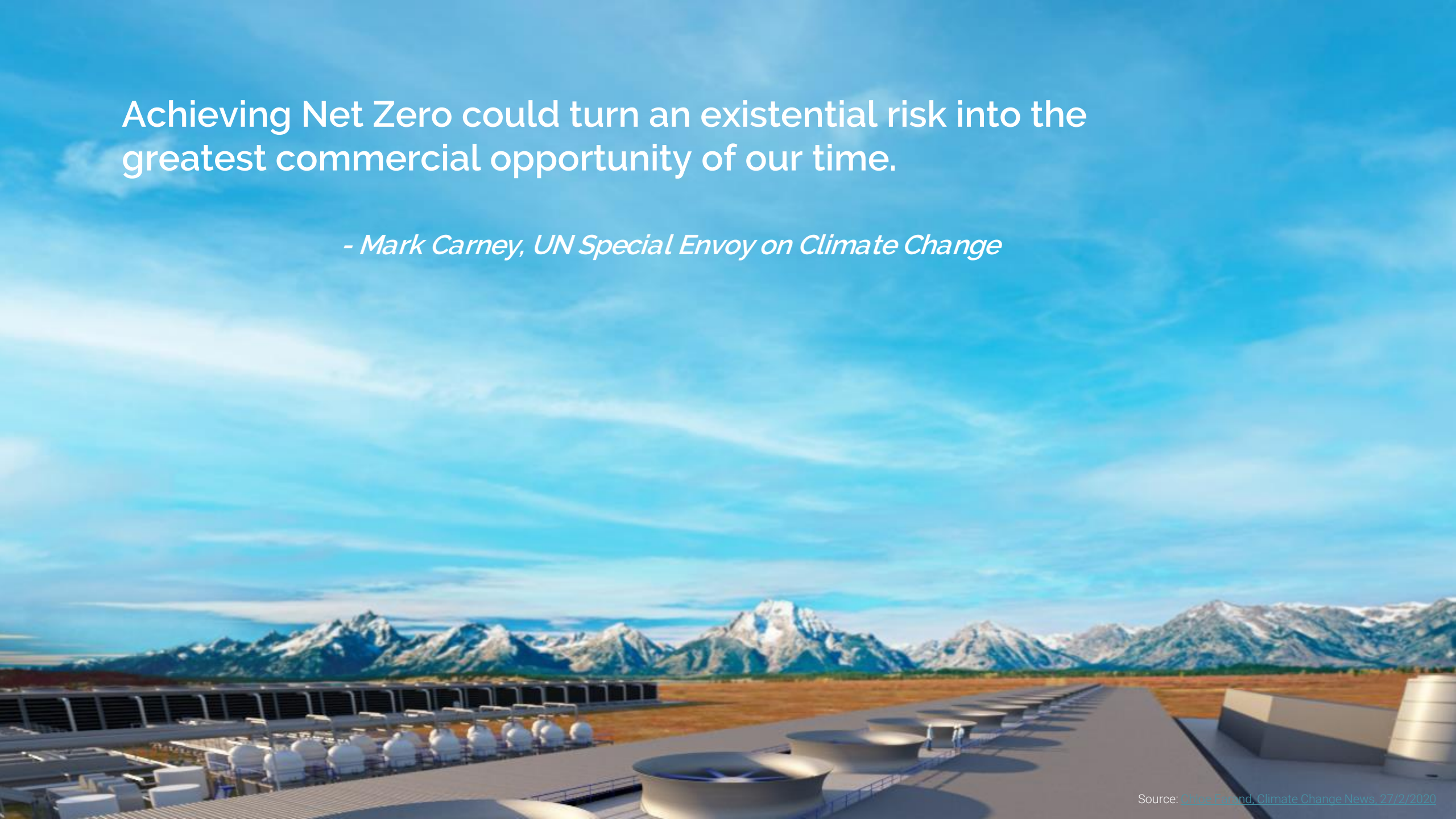
- DAC-based solutions will help bring the carbon cycle back into balance by safely removing and reusing atmospheric CO_2
- In the short term, DAC and AIR TO FUELS™ products will help abate hard-to-avoid emissions as we achieve net zero
- In the longer term, DAC will help to remove legacy CO_2 so that we can restore the climate



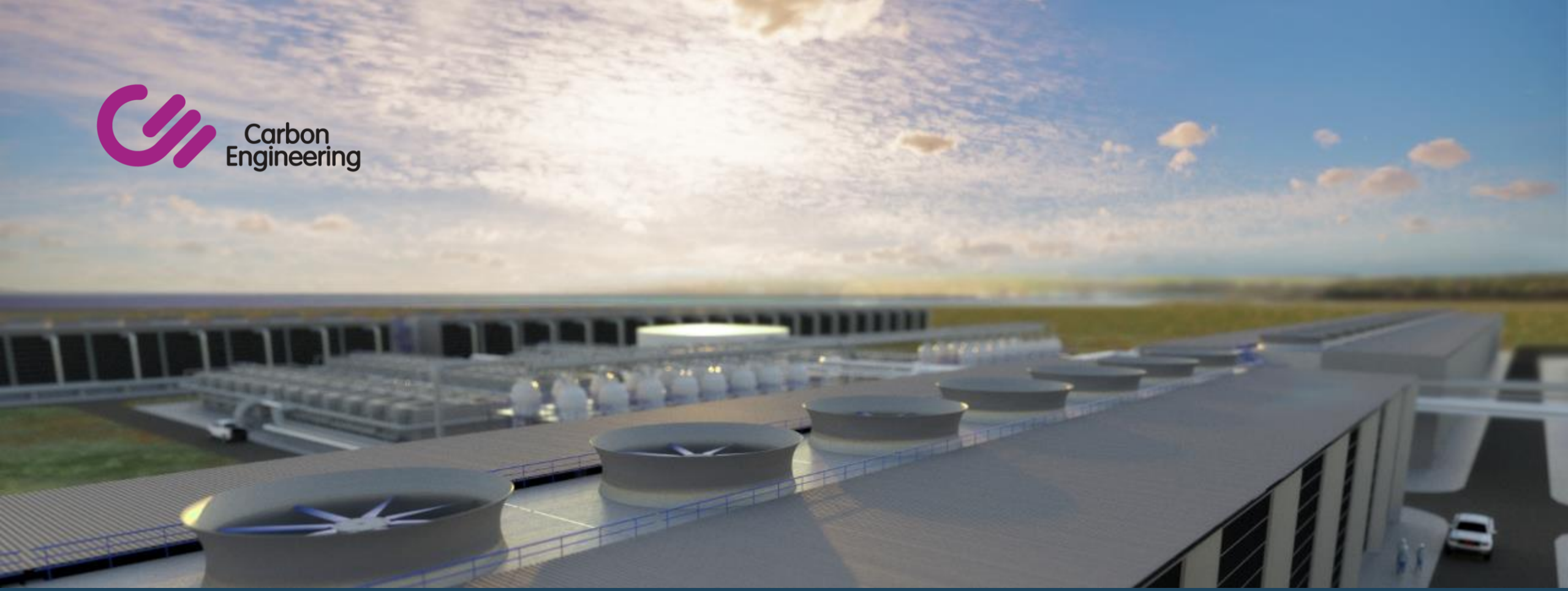
TOGETHER, WE CAN ACHIEVE NET ZERO AND BEYOND – TO CLIMATE RESTORATION

Achieving Net Zero could turn an existential risk into the greatest commercial opportunity of our time.

- Mark Carney, UN Special Envoy on Climate Change



Source: Chloe Farrand, Climate Change News, 27/2/2020



MORE INFORMATION CAN BE FOUND AT:

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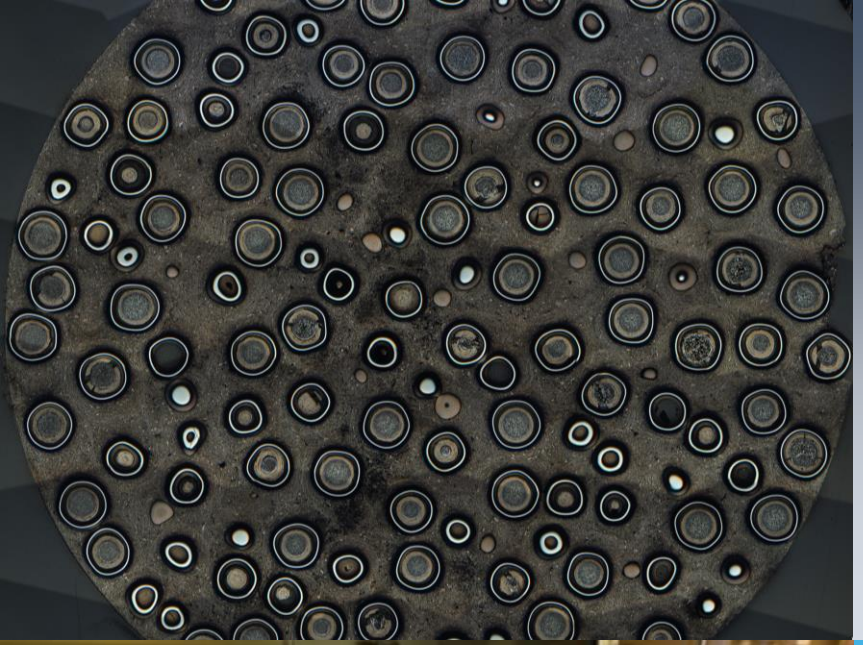
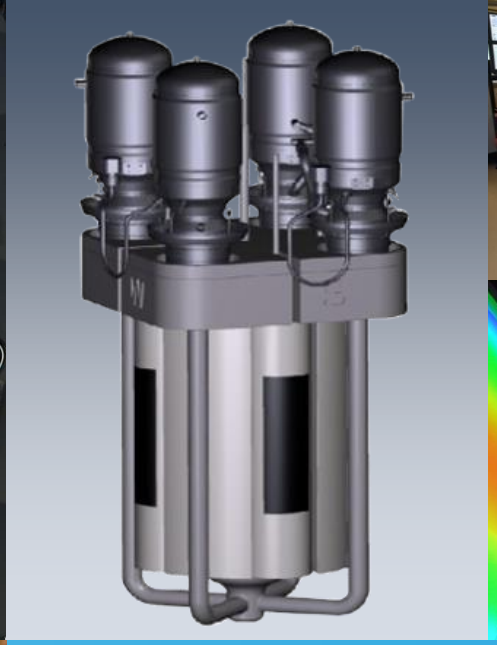
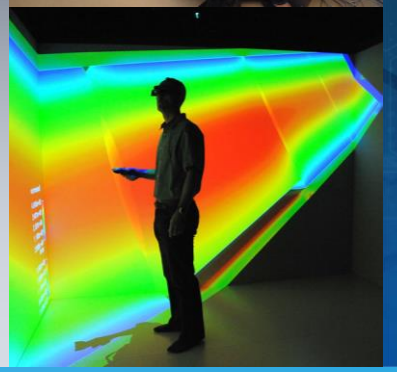






August 17, 2021

Dr. Richard Boardman
Light Water Reactor Sustainability Pathway Lead for Flexible Plant Operations and Generation

Dr. Shannon Bragg-Sitton
***N**ational Technical Director- NE Integrated Energy Systems*

Innovations in Nuclear Supported Clean Energy Systems

INL Idaho National Laboratory

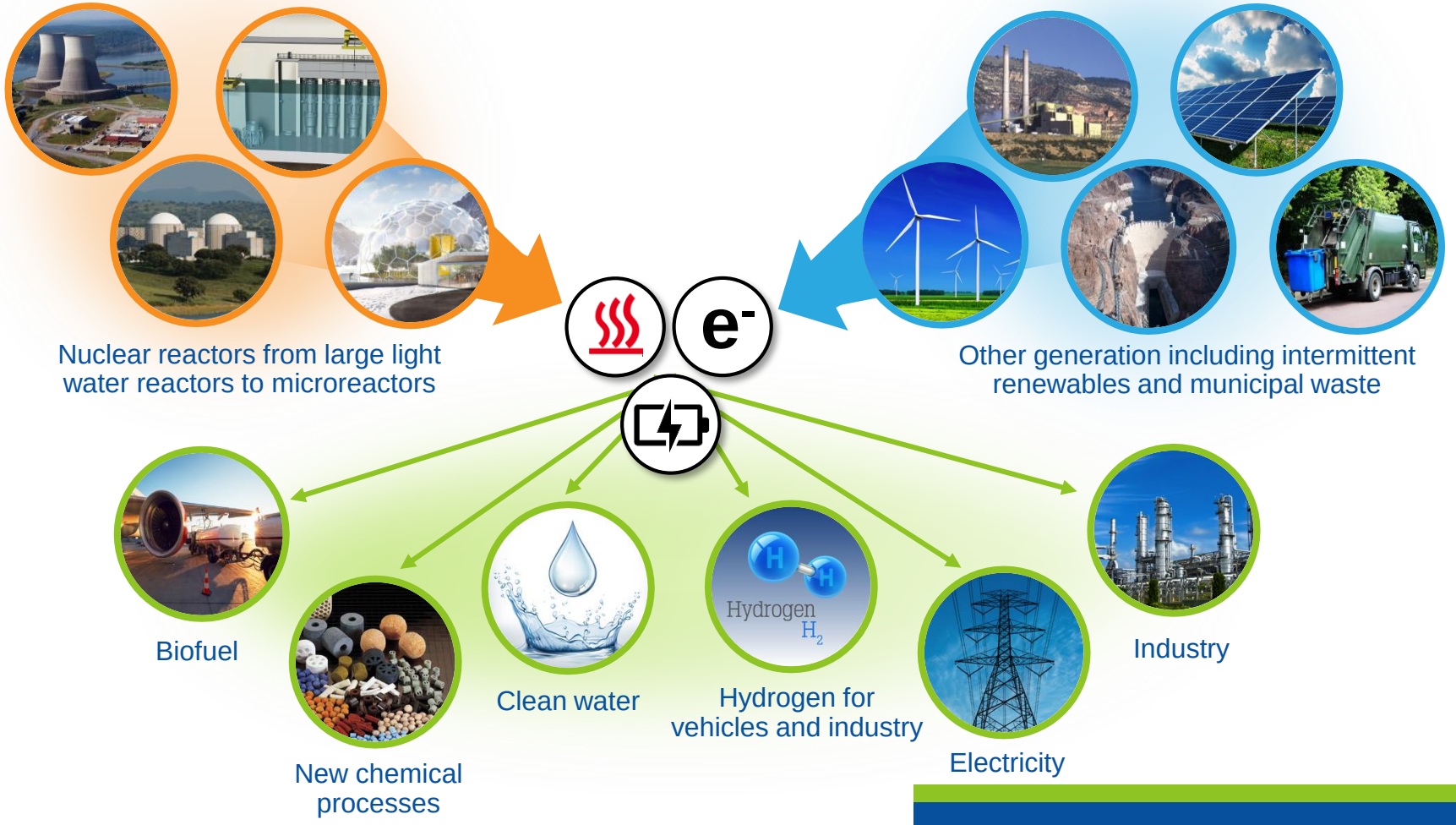
Transforming the energy paradigm

Today

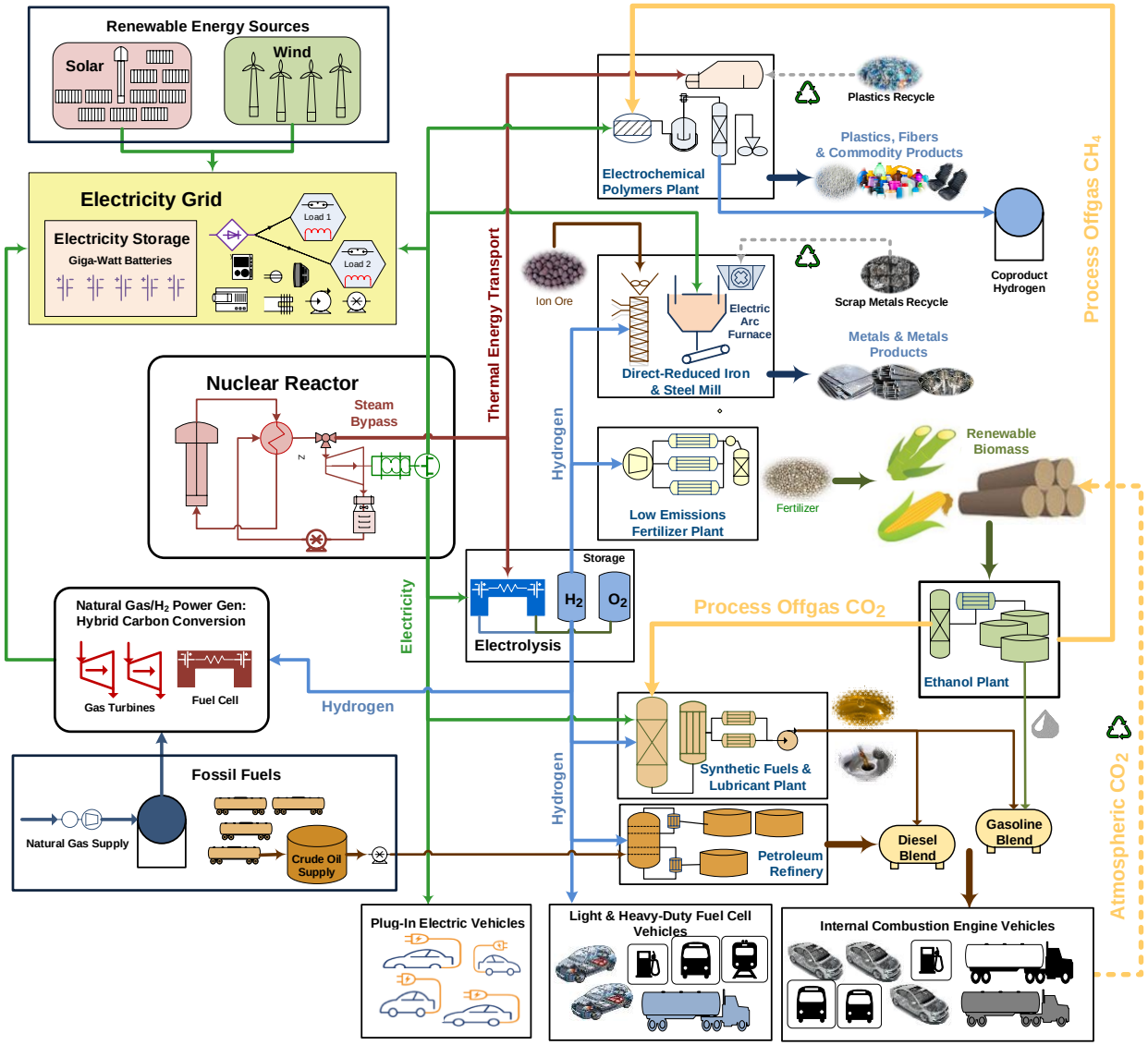
Electricity-only focus

Future Energy System

Integrated grid system leverages contributions from nuclear fission beyond electricity

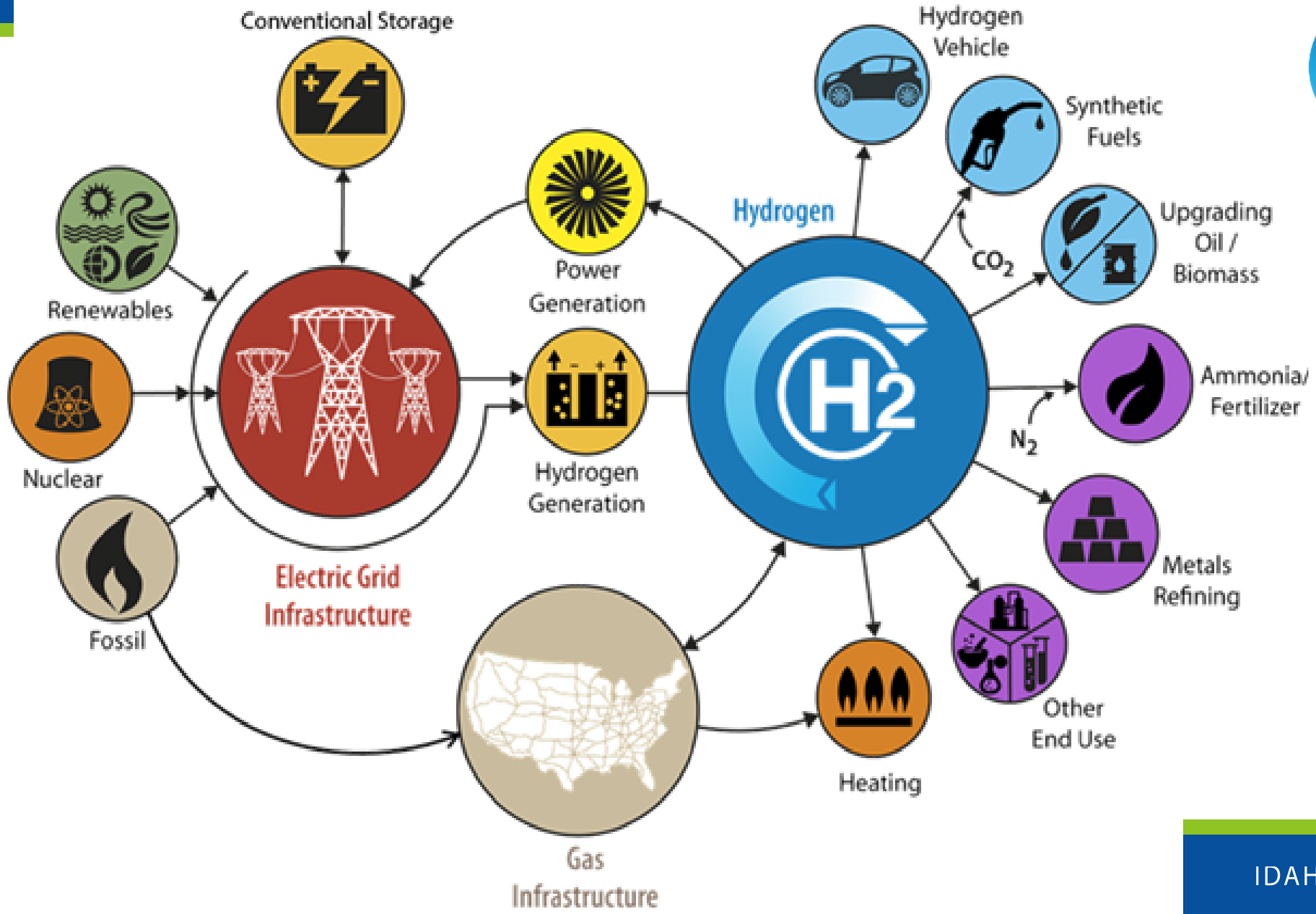


A new Paradigm: Integrated Energy Systems with Nuclear



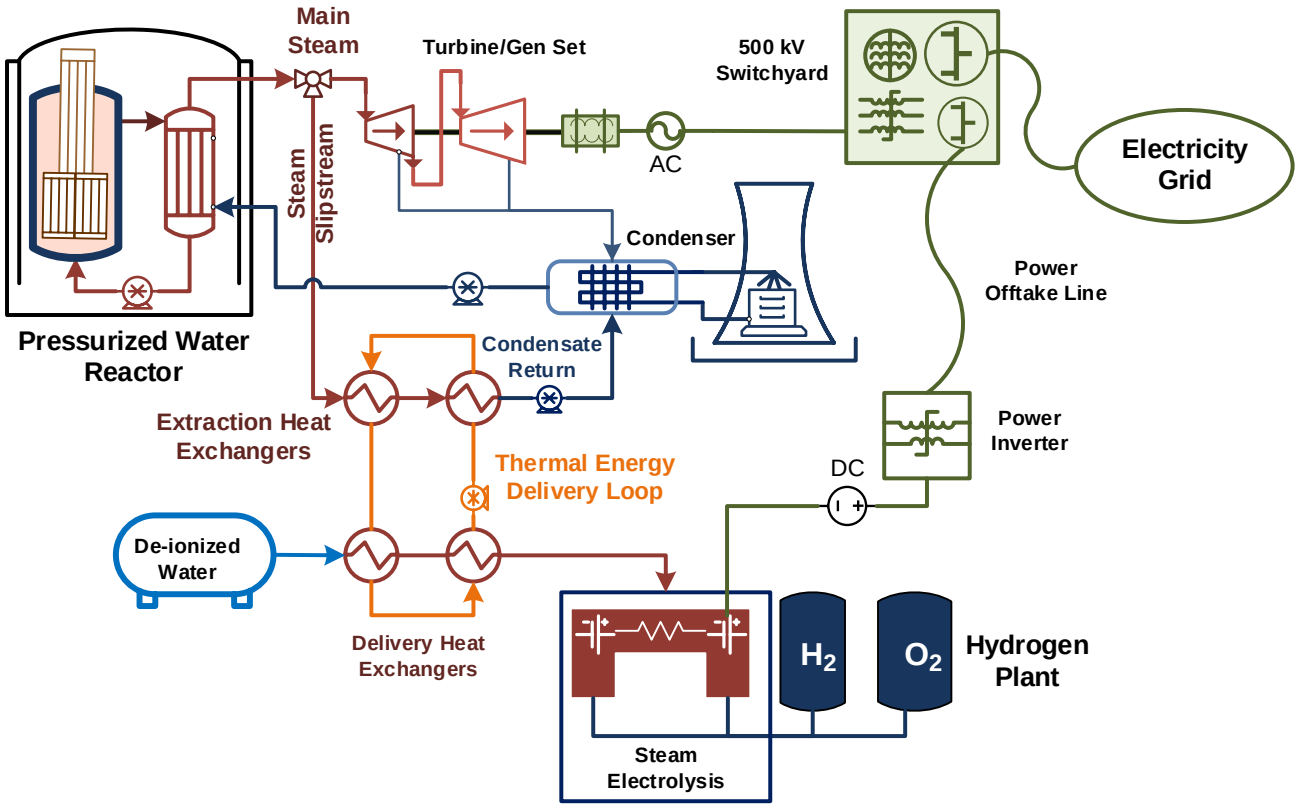
- **Industrial energy needs**
  - Electricity
  - Steam
  - Heat (Thermal Power)
- **Target Large Industries**
  - Transportation fuels
  - Fired heaters / Steam boilers
  - Polymers & Plastic
  - Iron & Steel
  - Fertilizers
  - Minerals
- **Keys to success**
  1. Hydrogen is key energy currency
  2. Flexible operations can support the grid
  3. Energy storage is imperative

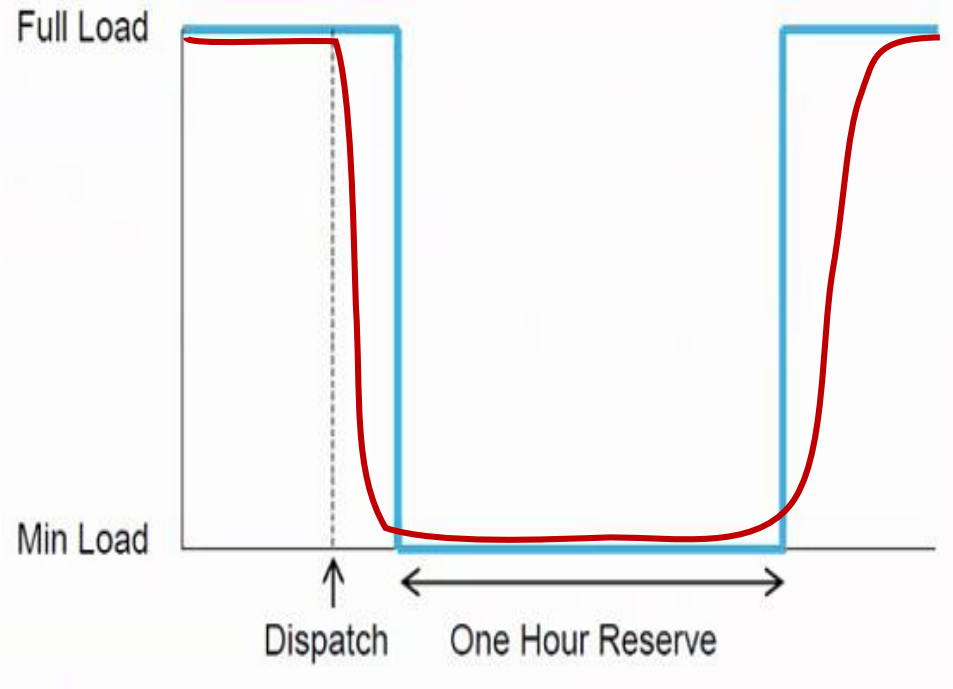
Large-Scale Hydrogen Markets



H2@Scale℠
U.S. Department of Energy

Electrolysis while dispatching as spinning or non-spinning reserves

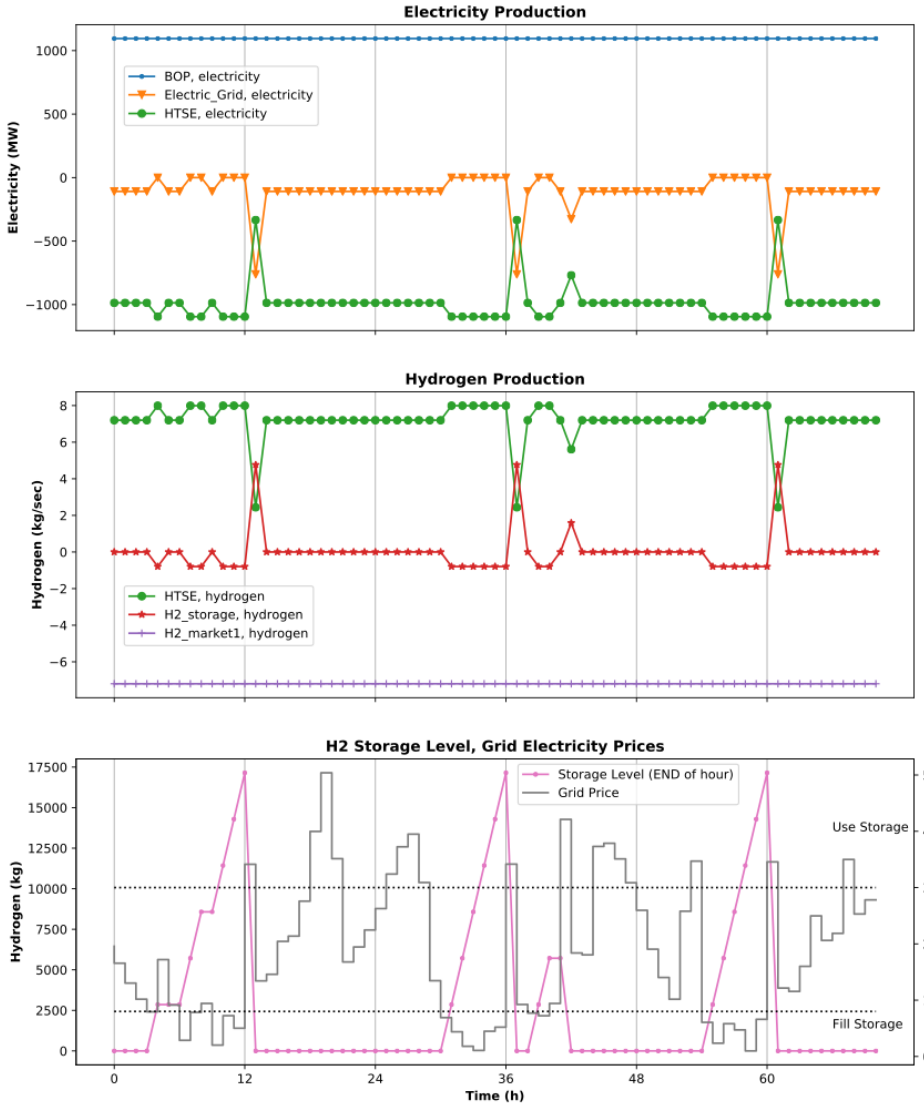


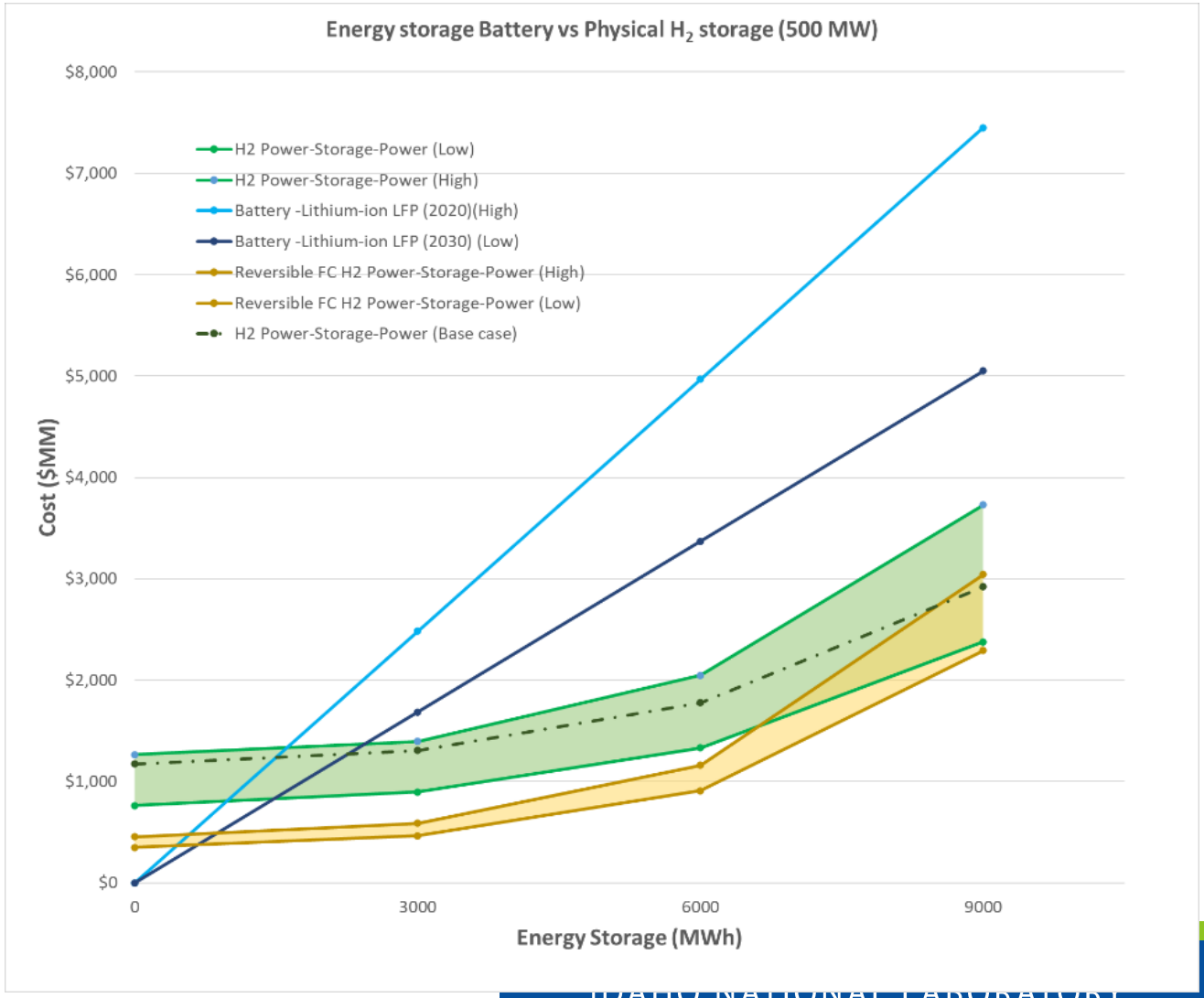


LWRS LIGHT WATER REACTOR SUSTAINABILITY

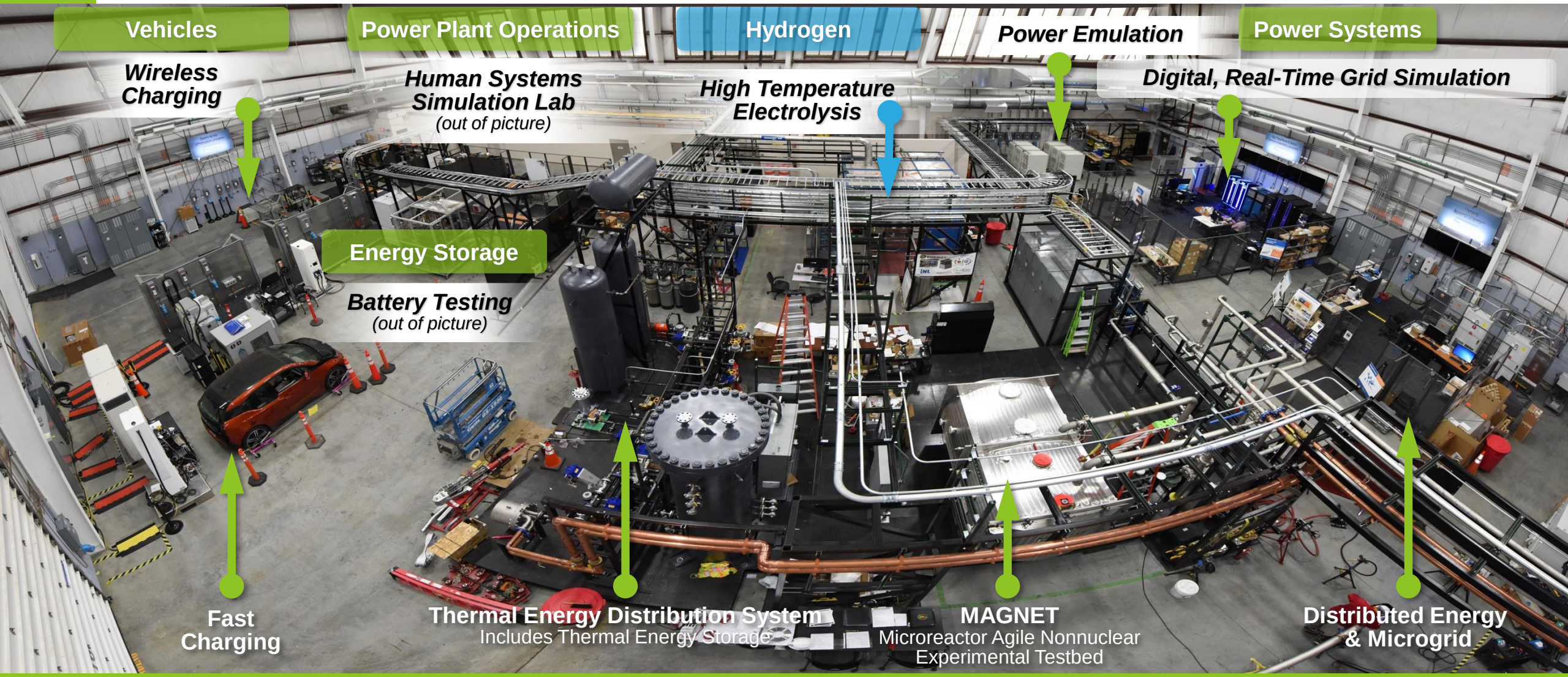
H2@Scale U.S. Department of Energy

Market Arbitrage: Buy low, Sell high





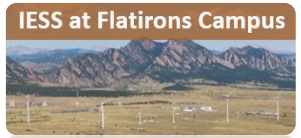
Integrating systems for the nation's net-zero future



Tri-Lab Demonstration of Integrated Energy Systems

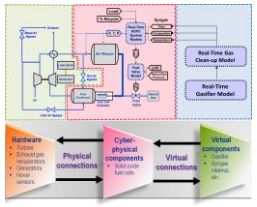
ARIES

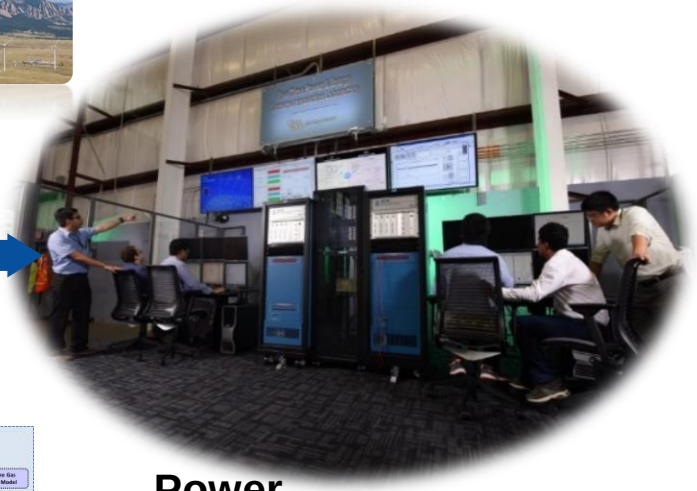
IESS at Flatirons Campus



NREL
Transforming ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY





Power Hardware and Grid-in-the-Loop

Human-in-the-Loop

Hydrogen and other Flexible Industrial Processes

Thermal Energy Generation and Transport

Joint EERE-NE H_2 Production Demonstration Projects

Three projects have been announced for demonstration of hydrogen production at nuclear power plants

- Demonstrate hydrogen production using direct electrical power offtake from a nuclear power plant
- Develop monitoring and controls procedures for scaleup to large commercial-scale hydrogen plants
- Evaluate power offtake dynamics on NPP power transmission stations to avoid NPP flexible operations
- Produce hydrogen for captive use by NPPs and first movers of clean hydrogen

Schedule:

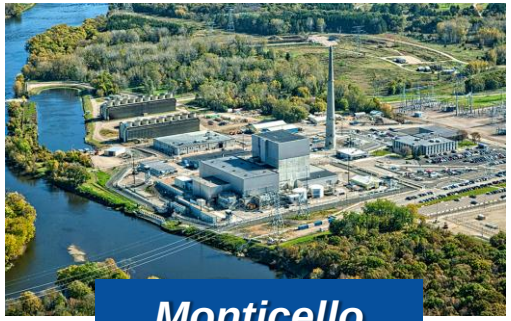
- Exelon: Nine-Mile Point NPP; LTE/PEM Vendor 1; using “house load” power; PEM skid testing is underway at NREL; H2 production beginning ~Jan. 2022
- Energy Harbor; LTE/PEM Vendor 2; power provided by completing plant upgrade with new switch gear at the plant transmission station; installation to be made at next plant outage; contract start anticipate by Oct. 2022
- Xcel Energy: HTE/SOEC Vendor 1; Project negotiations are being finalized. Tie into plant thermal line engineering is being planned; Official project start anticipated around Jan. 2022.

Davis-Besse Nuclear Power Plant LTE-PEM Vendor 1

Nine Mile Point Nuclear Power Plant LTE/PEM Vendor 2

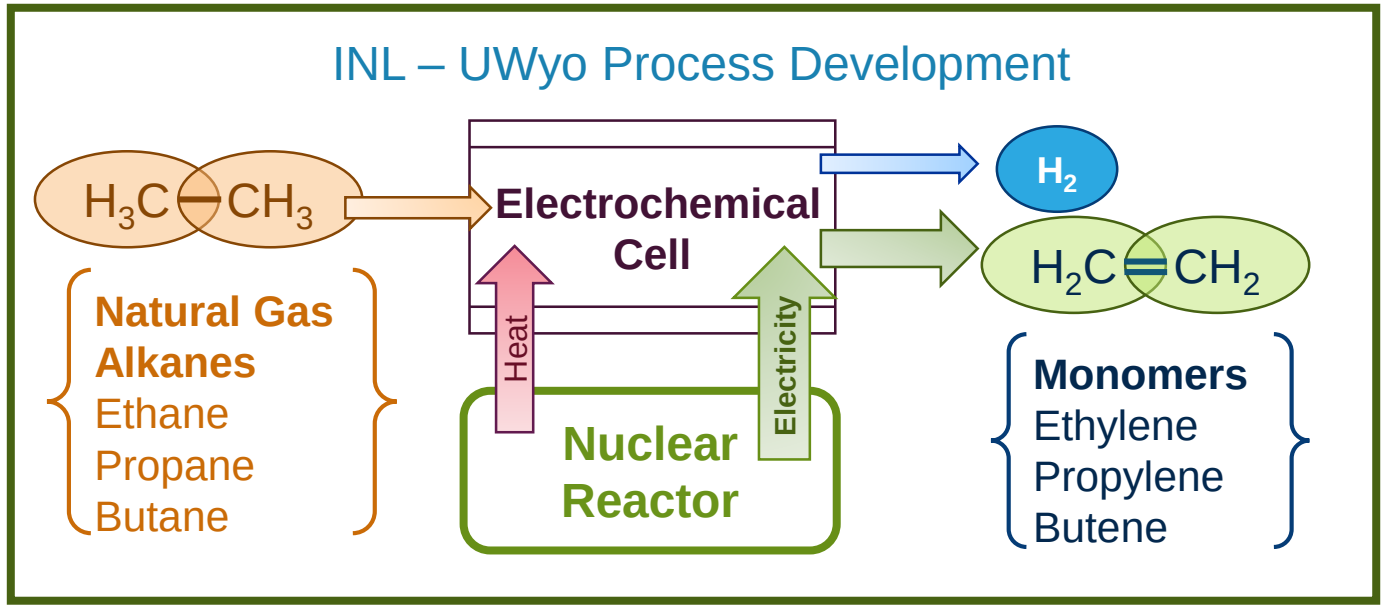
Thermal & Electrical Integration at an Xcel Energy Nuclear Plant HTE/Vendor 1

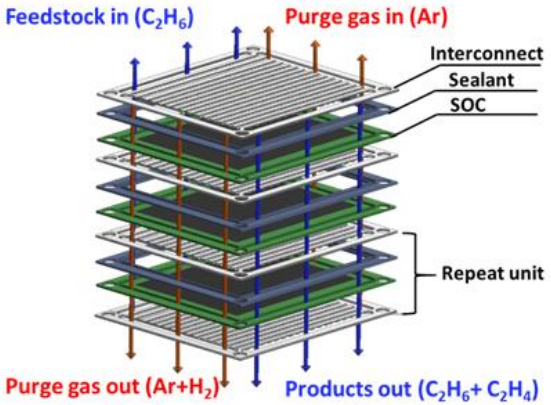
Prairie Island

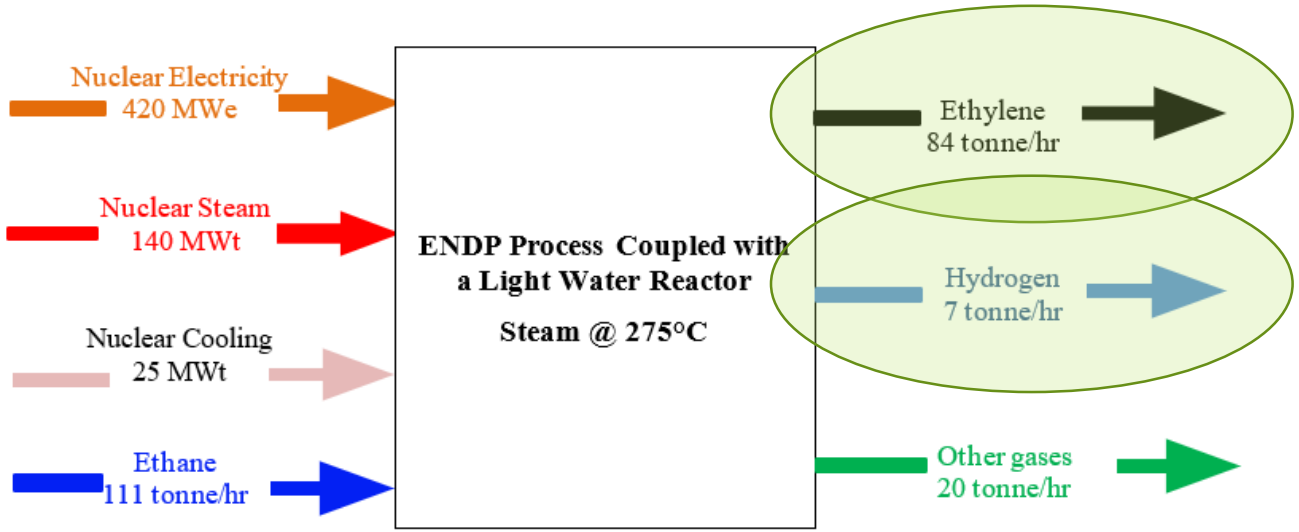


Monticello

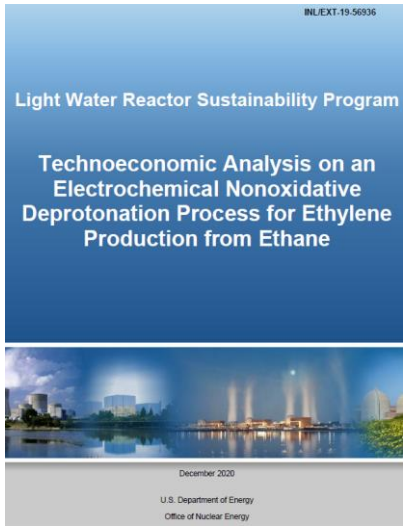
Electrochemical Conversion of Natural Gas Condensates into Polymers & Hydrogen



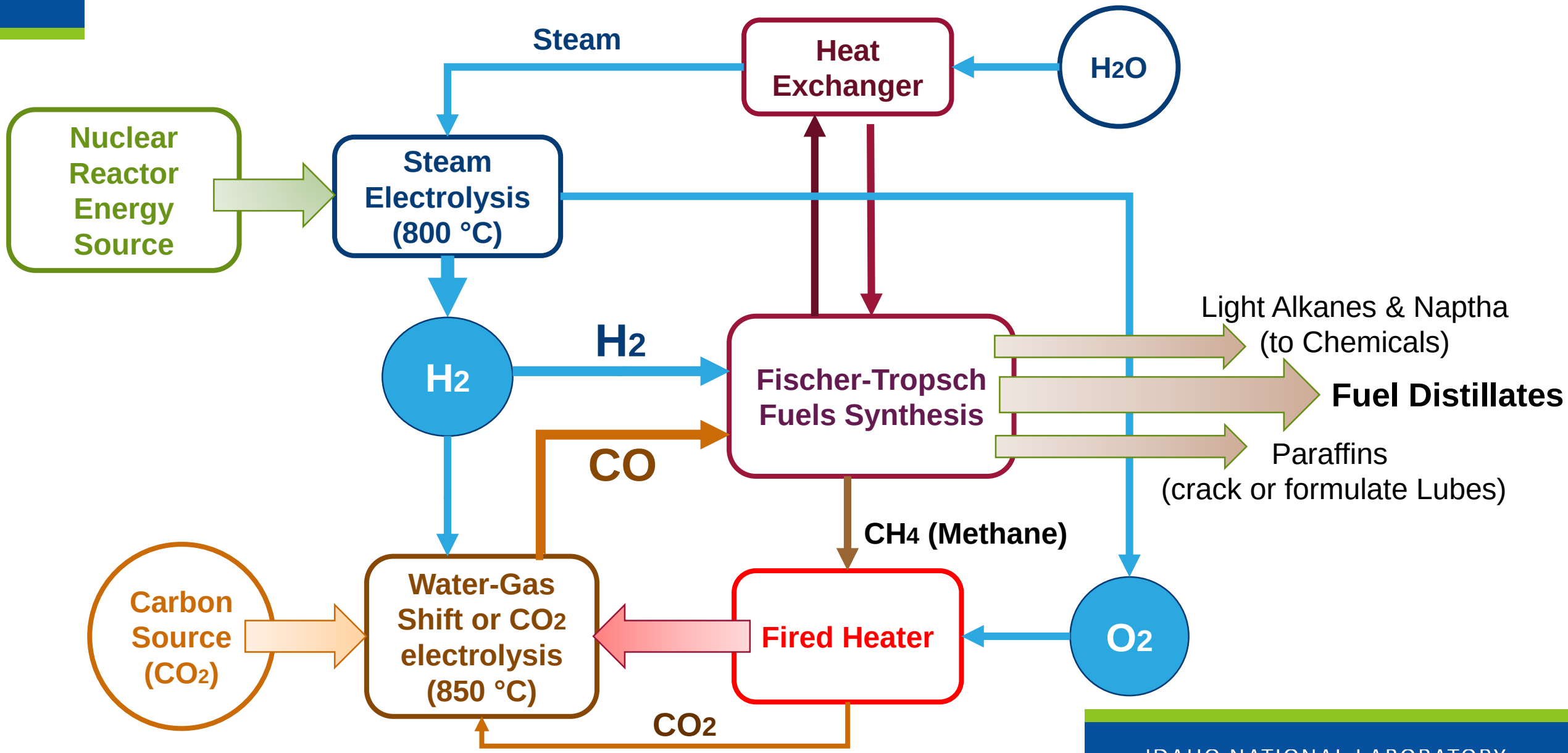




High Value Premium Products

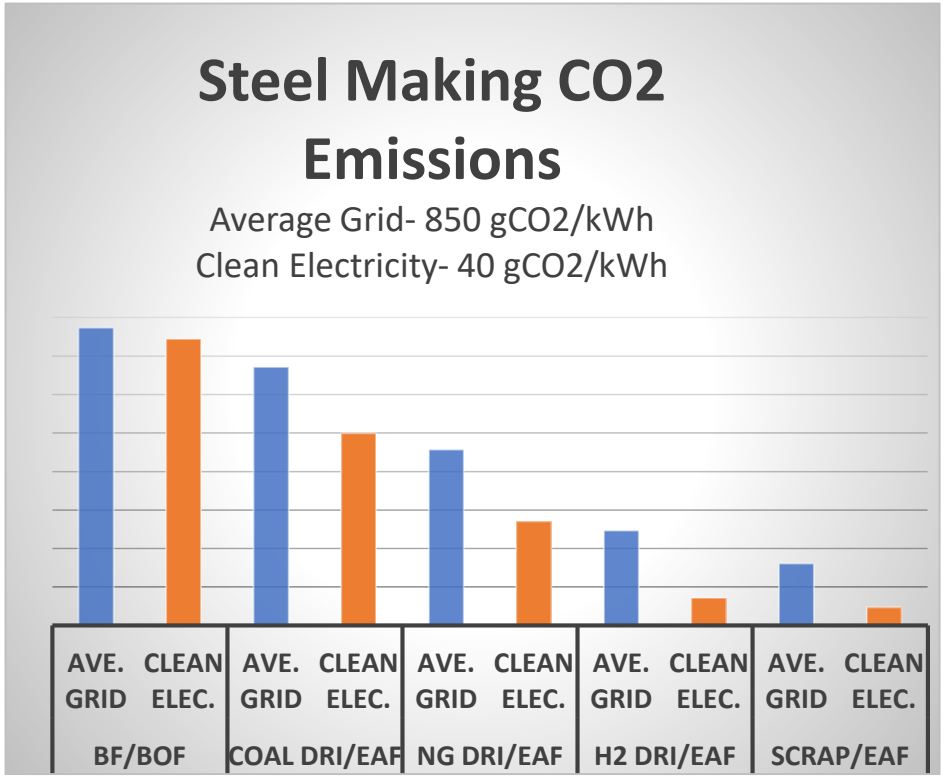


F.T. Carbon Conversion to Fuels and Chemicals (CCU)



Iron and Steel Making

- Flash-Iron Technology
- Direct reduced iron with hydrogen
- Scalable to mini-mills
- Fed directly to electric-arc furnace



Large-scale bench reactor facility layout
Photo credit Berry Metal Company

Pilot plant at University of Utah:
Professor HY Sohn

Advanced reactor future state: One size does not fit all

Researchers at Idaho National Laboratory are collaborating with industry and academia to develop nuclear reactor concepts of various sizes for various use cases.

Advanced Reactor Design Concepts

Benefits:

- Enhanced safety
- Versatile applications
- Reduce waste
- Use advanced manufacturing to save money

60+ private sector projects under development

SIZES

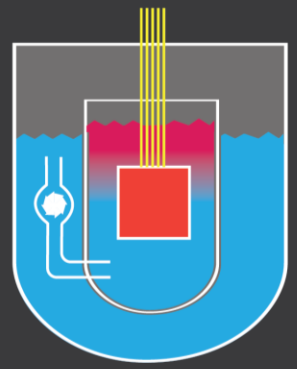
SMALL
1 MW to 20 MW
Micro-reactors
Can fit on a flatbed truck. Mobile. Deployable.

MEDIUM
20 MW to 300 MW
Small Modular Reactors
Factory-built. Can be scaled up by adding more units.

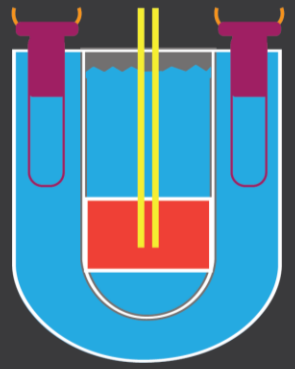
LARGE
300 MW to 1,000 + MW
Full-size Reactors
Can provide reliable, emissions-free baseload power

Advanced Reactors Supported by the U.S. Department of Energy

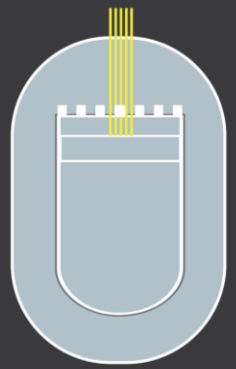
TYPES



MOLTEN SALT REACTORS – Use molten fluoride or chloride salts as a coolant. Online fuel processing. Can re-use and consume spent fuel from other reactors.



LIQUID METAL FAST REACTORS - Use liquid metal (sodium or lead) as a coolant. Operate at higher temperatures and lower pressures. Can re-use and consume spent fuel from other reactors.



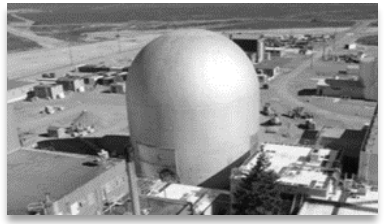
GAS-COOLED REACTORS – Use flowing gas as a coolant. Operate at high temperatures to efficiently produce heat for electric and non-electric applications.

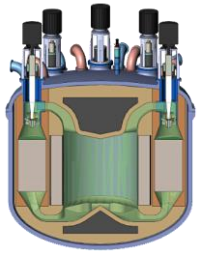
Accelerating advanced reactor demonstration and deployment

MARVEL
DOE
2022-2023

Project Pele Microreactor
DoD
2023-2024

DOME Test Bed
NRIC
2023-2024

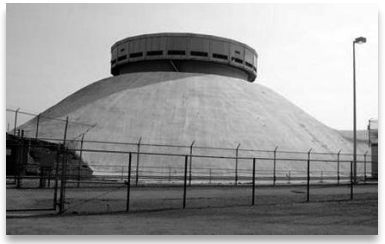


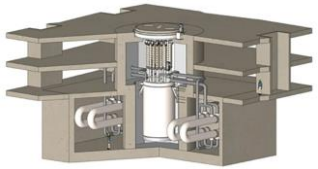


MCRE
Southern Co. & TerraPower
2025

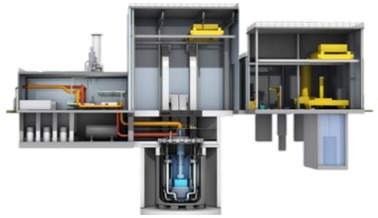
TerraPower
Southern Company

LOTUS Test Bed
NRIC
2024





Hermes
Kairos
Kairos Power 2026

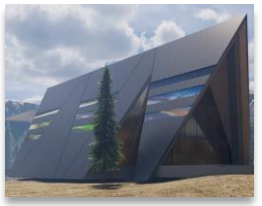


Natrium Reactor
TerraPower & General Electric
2028

TerraPower
HITACHI

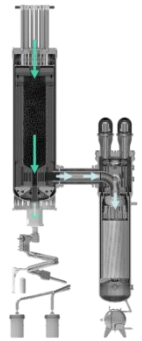
Aurora
Oklo Inc.
TBD

OKLO



Xe-100
X-energy
2027

energy



SMR
UAMPS &
NuScale
2029

UAMPS
NUSCALE
Power for all humankind

2030

NRIC National Reactor Innovation Center

Idaho National Laboratory