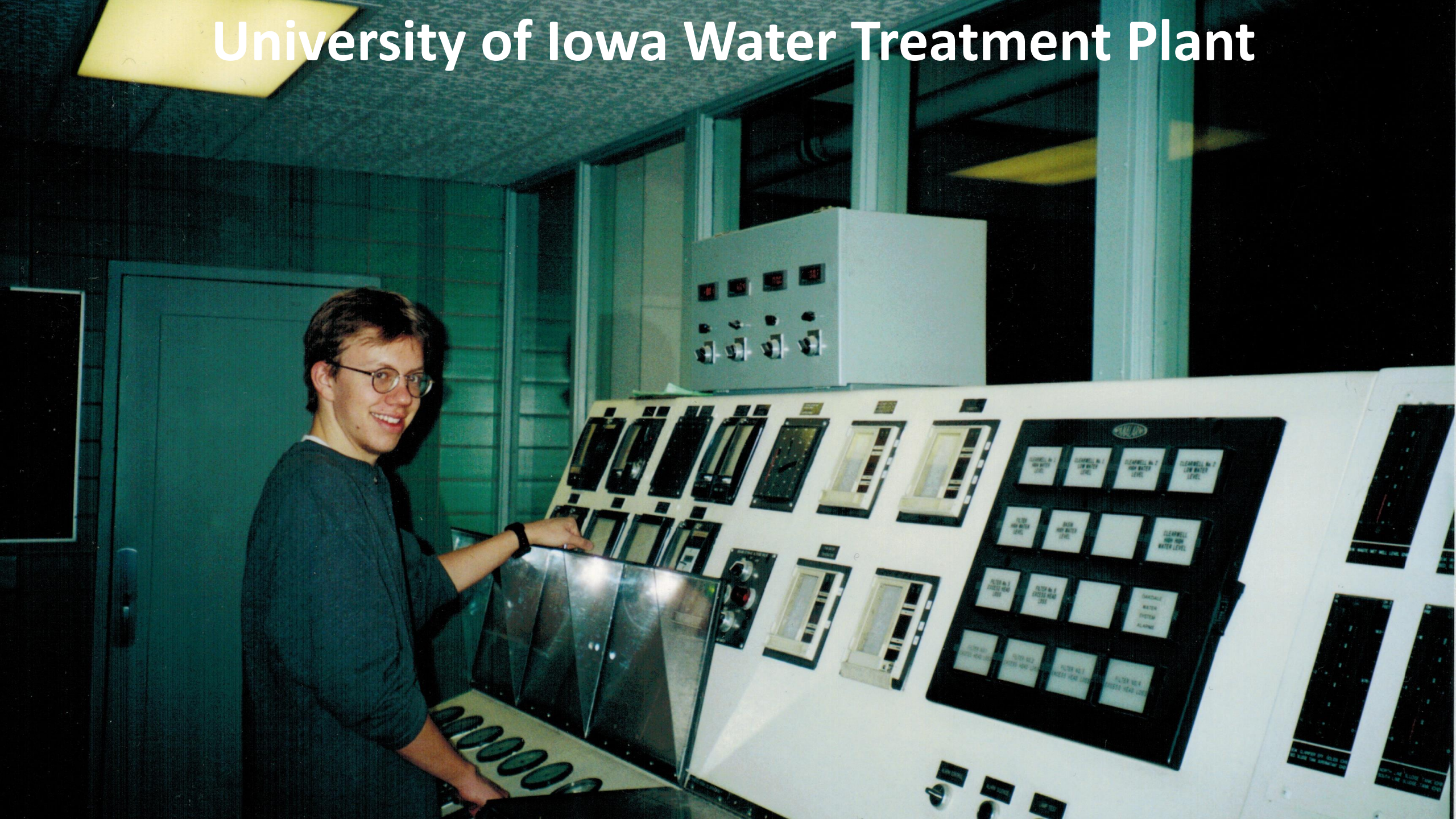
Water Implications for the Energy Evolution away from Emitting CO_2

Franek Hasiuk, PhD

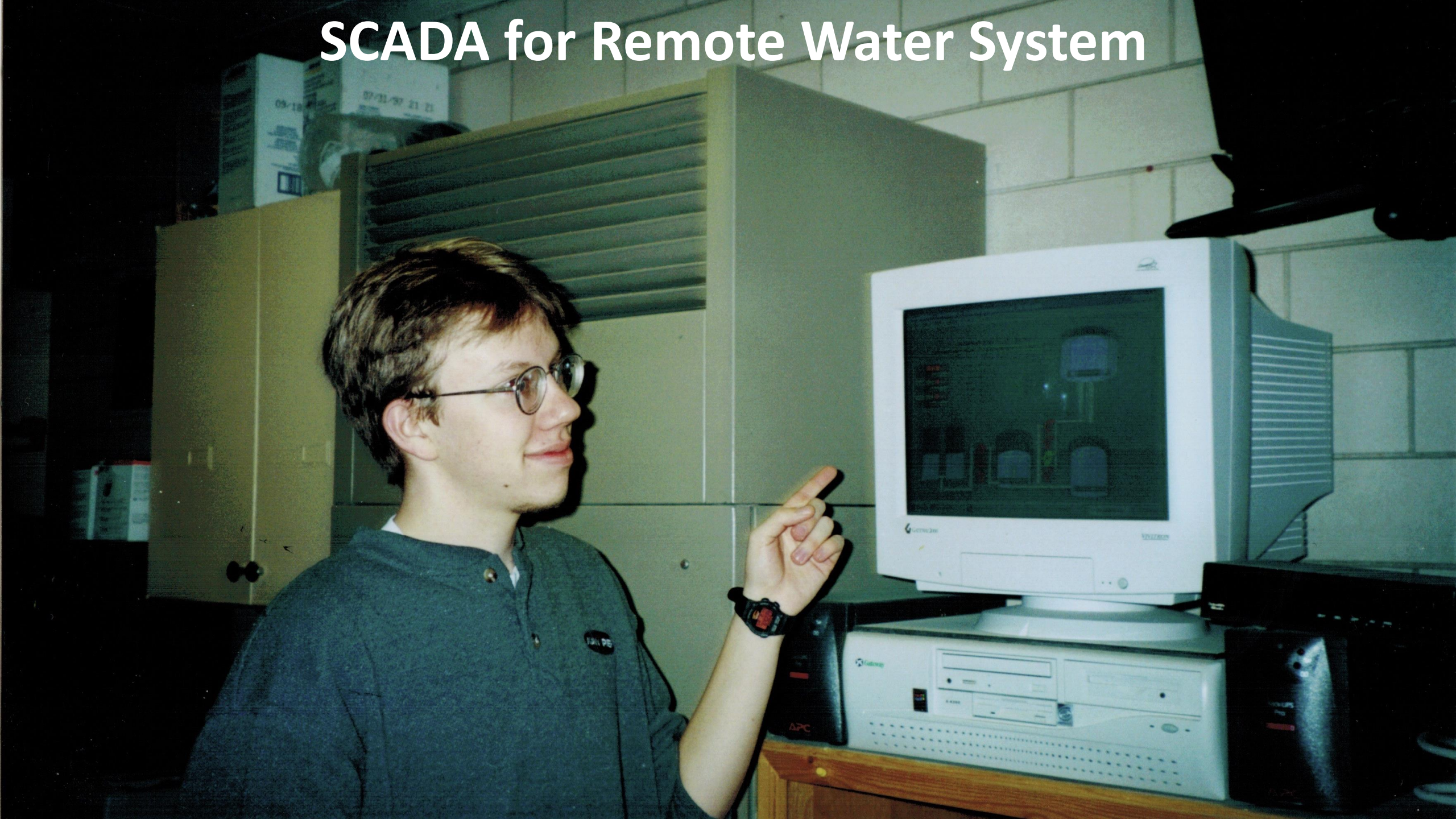
Governor's Water Conference

Manhattan, KS • 17 Nov 2022

University of Iowa Water Treatment Plant

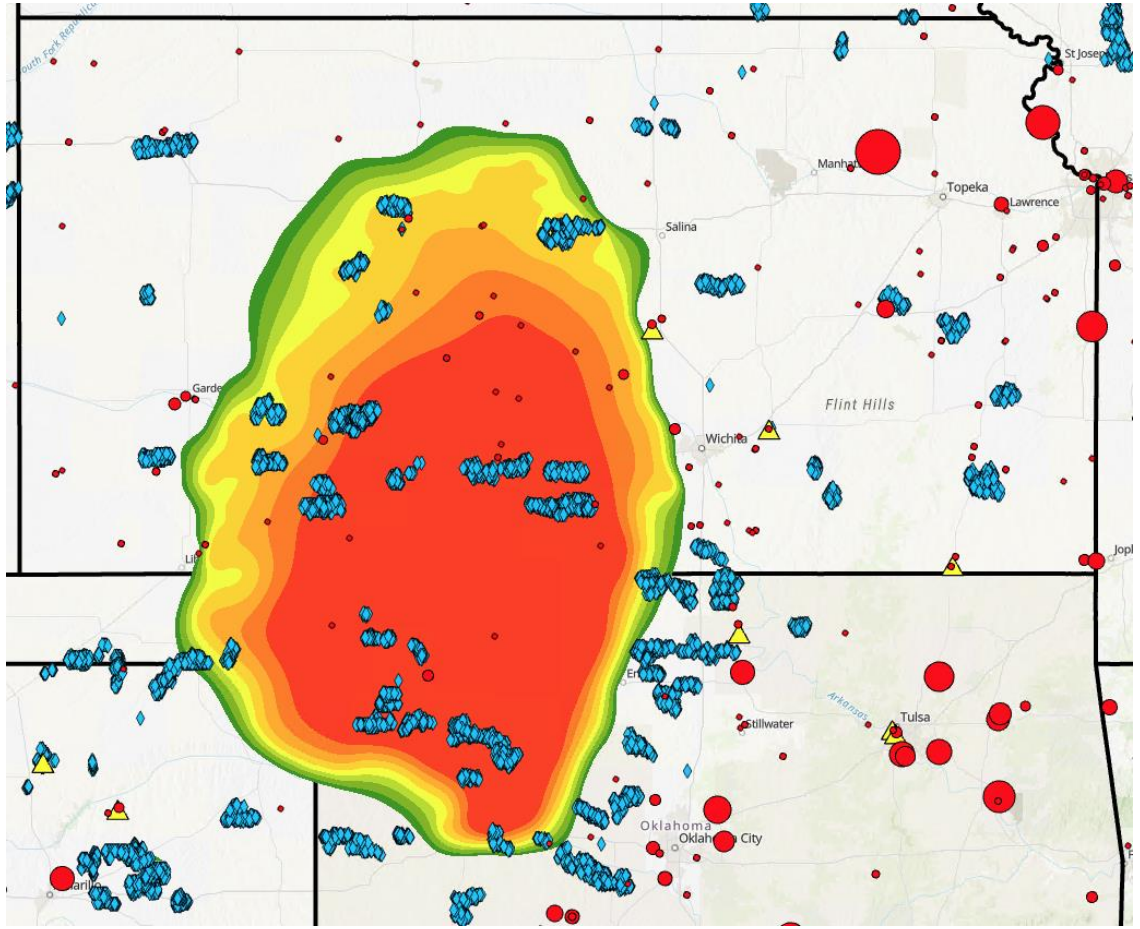


SCADA for Remote Water System



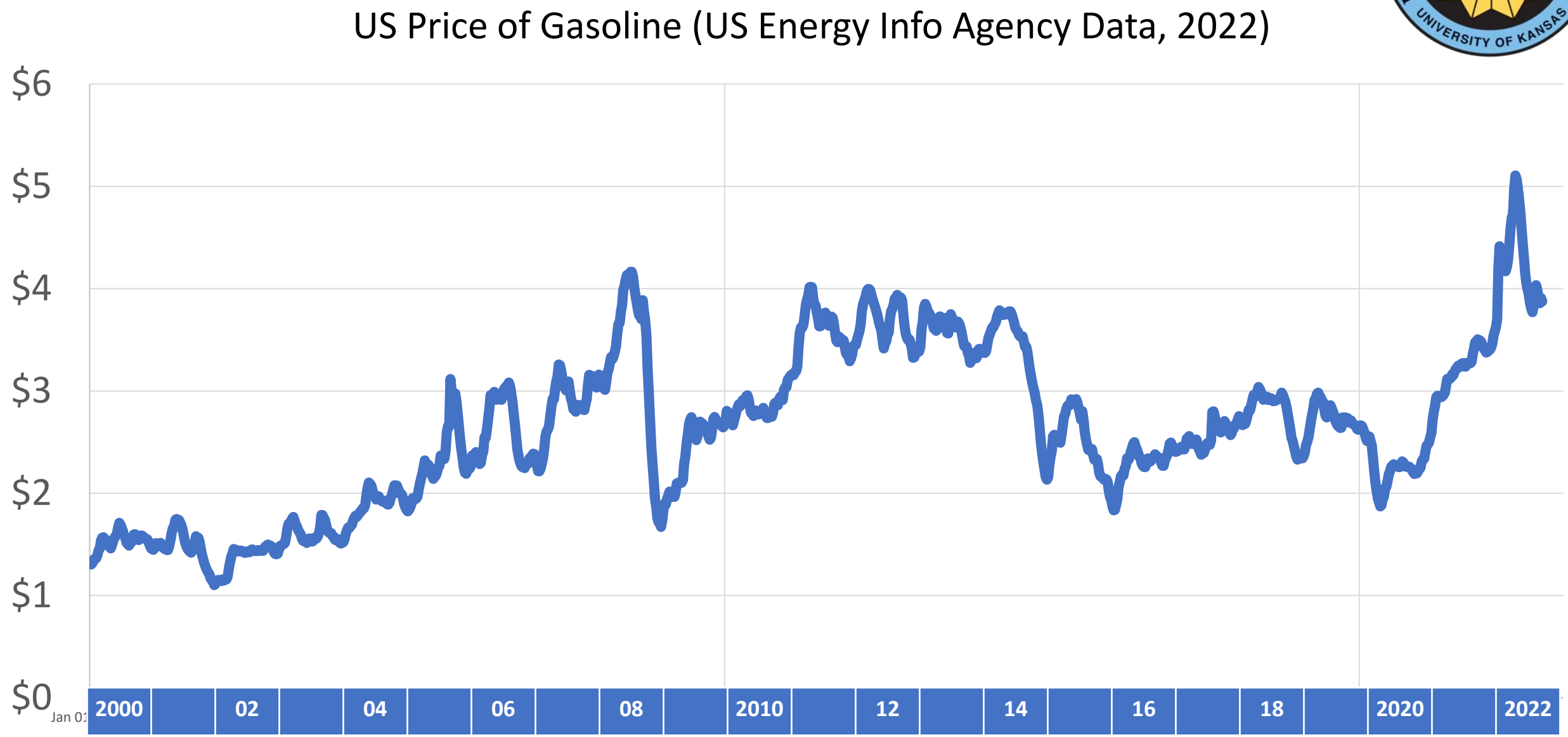
Summary

- Evolution away from emitting carbon dioxide underway
- Increased deployment of renewable energy requires more energy storage
- Energy Storage systems will change how we use water
- Creativity during this evolution can free us from entrenched views on water in Kansas



Common Model for Energy Evolution

2020 Test of this Model

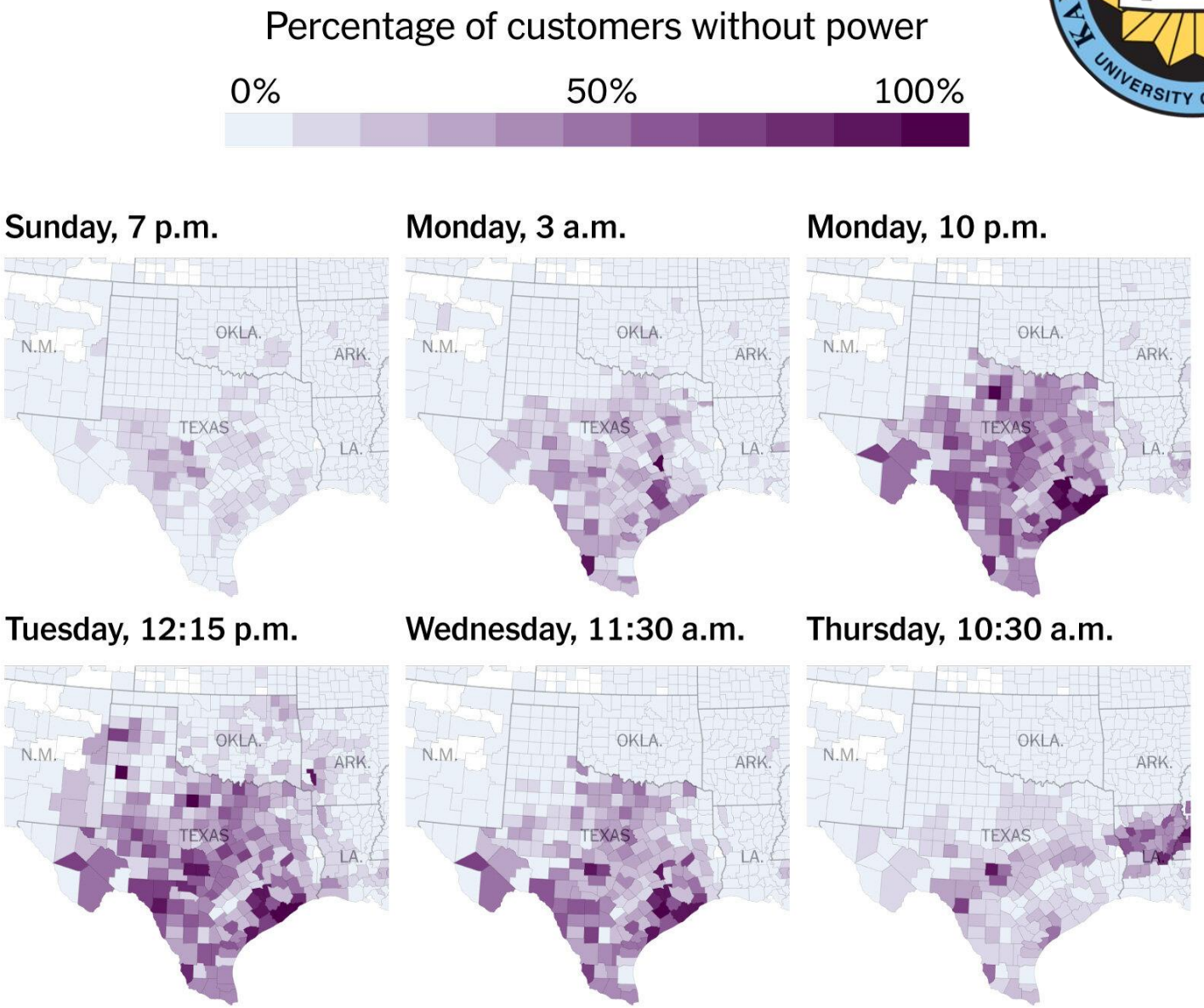


2021 Test of this Model

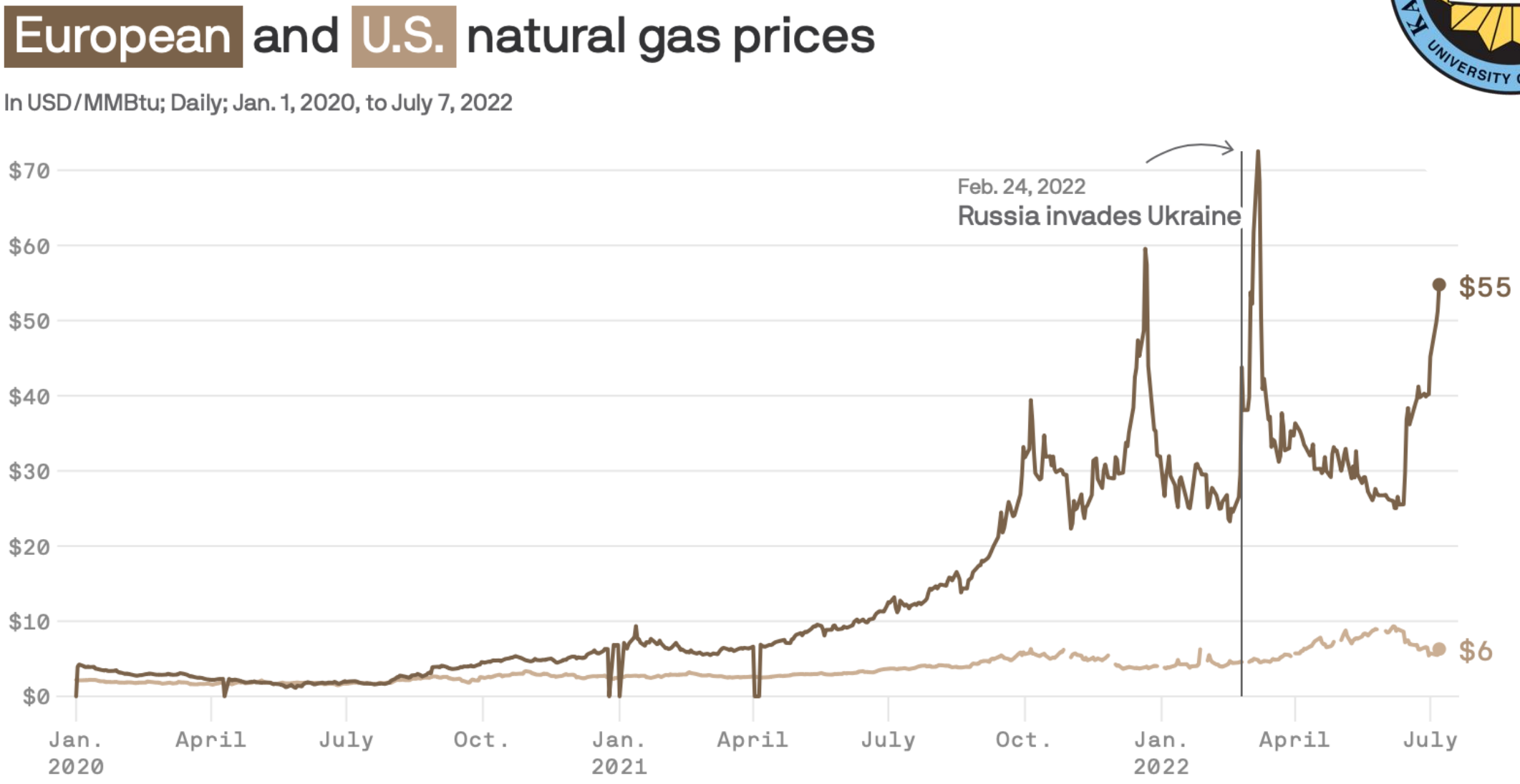
Winterstorm Yuri

February 10–27, 2021

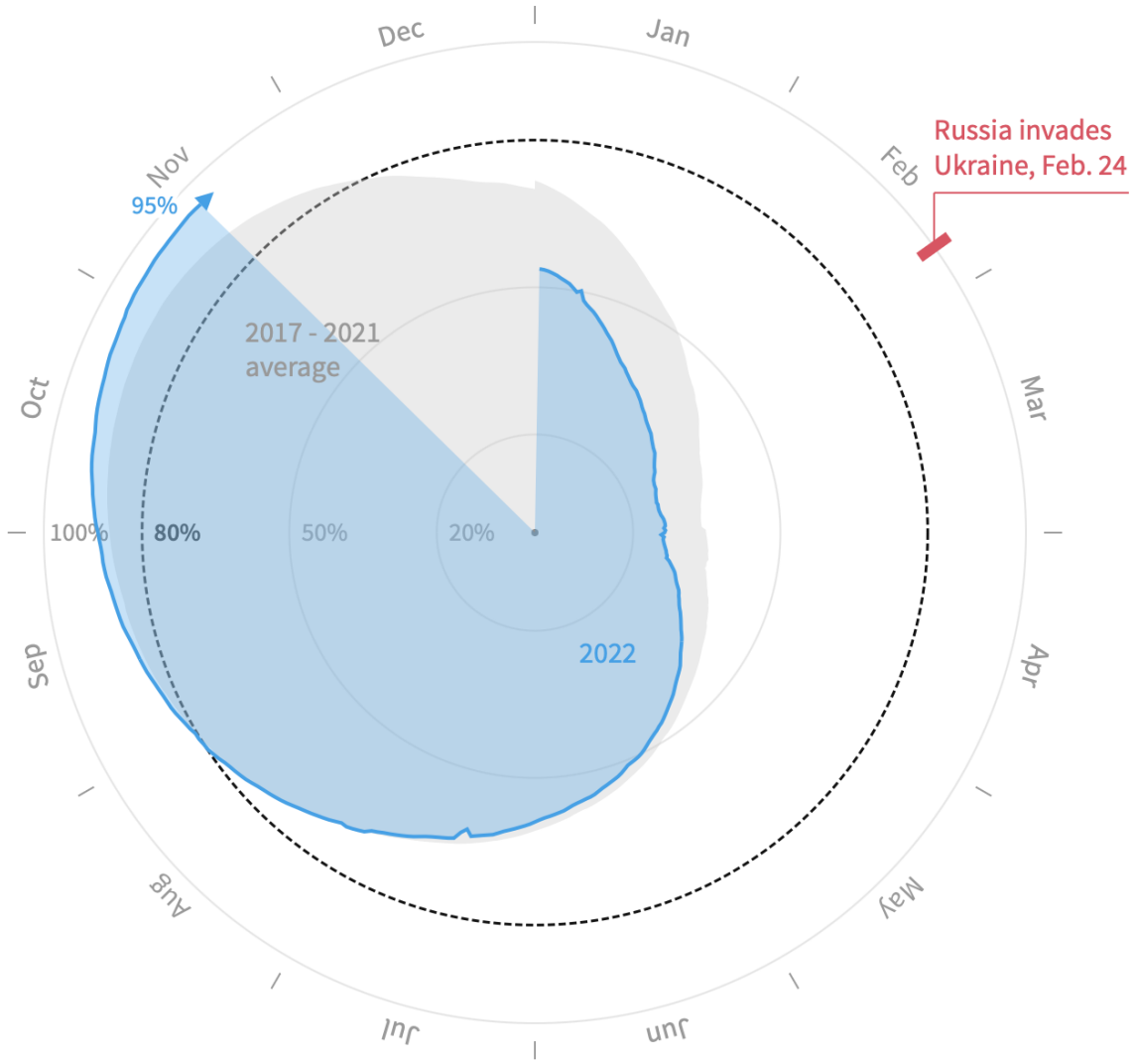
$195 Billion
in property damage

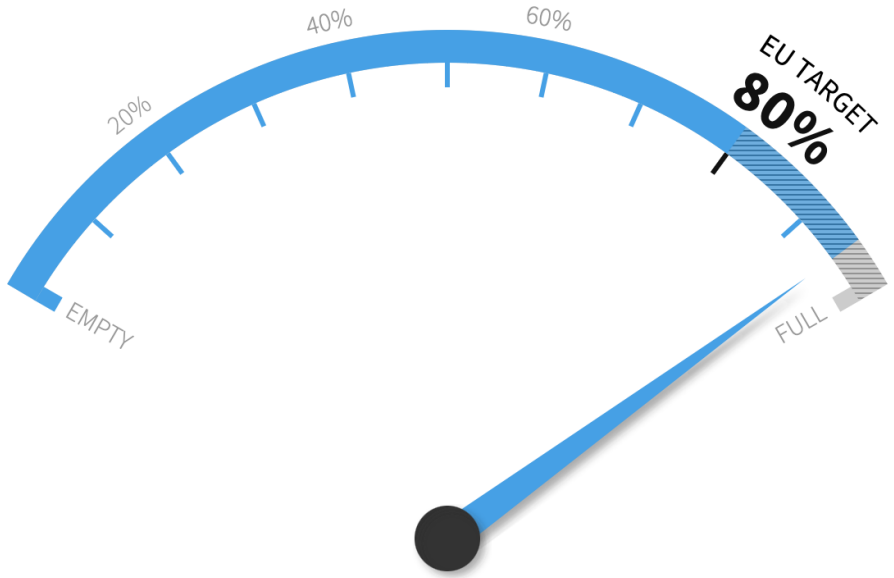


2022 Test of this Model



Europe has raced to fill gas storage





95.5% of EU gas storage is filled.

UPDATED NOV. 14, 2022

Reuters

NPR Story THIS MORNING!

CLIMATE

The crucial need for energy storage is key to the future of clean energy

November 17, 2022 · 5:08 AM ET

Heard on Morning Edition

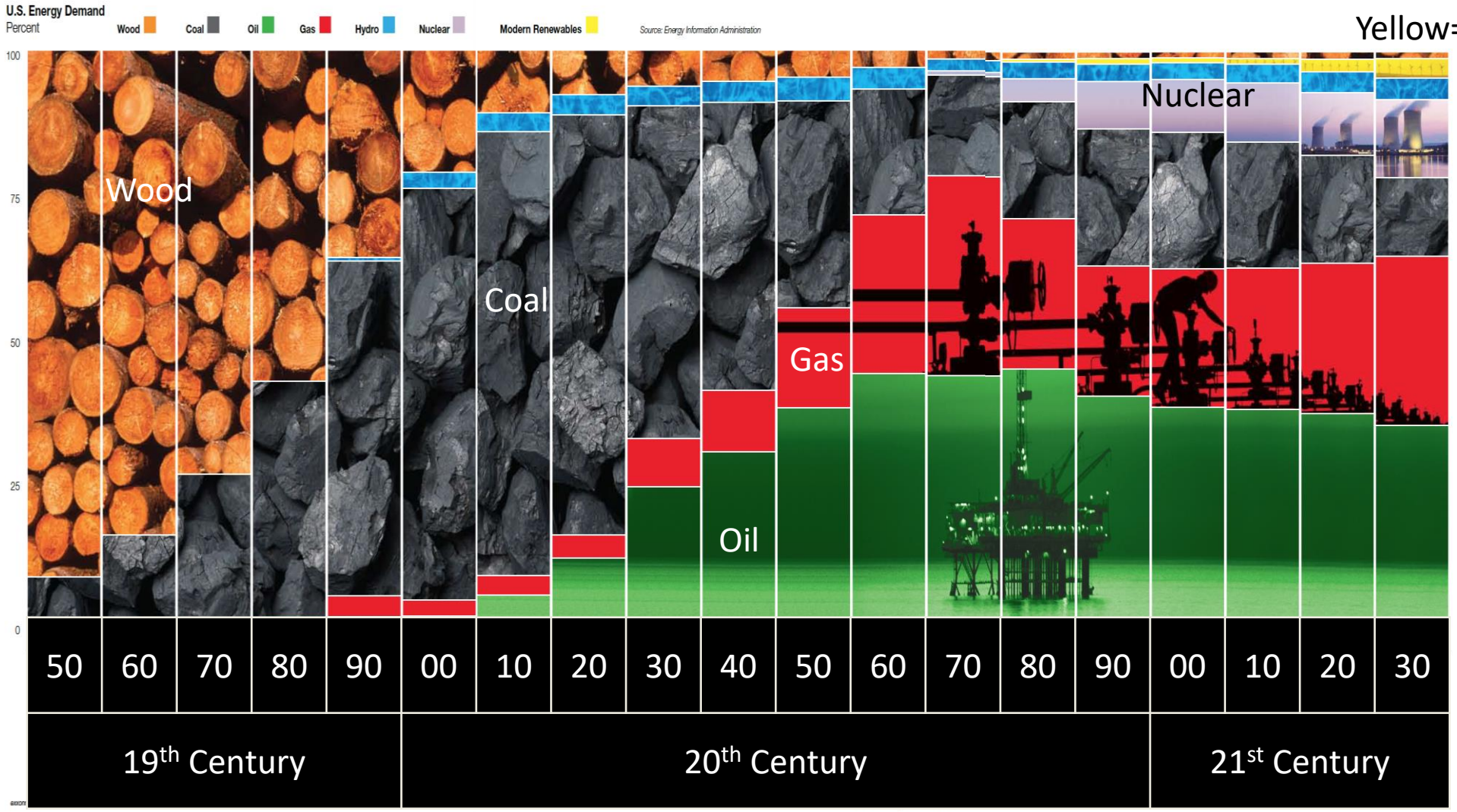
7-Minute Listen + PLAYLIST

NPR's Steve Inskeep speaks with George Crabtree, director of the Joint Center for Energy Storage Research, about the critical role of energy storage in achieving a clean energy future.

This model is idealistic and simplistic

Our future energy system will be *diverse*

US Fuel Use, 1830 to Today



Yellow=Solar/Wind

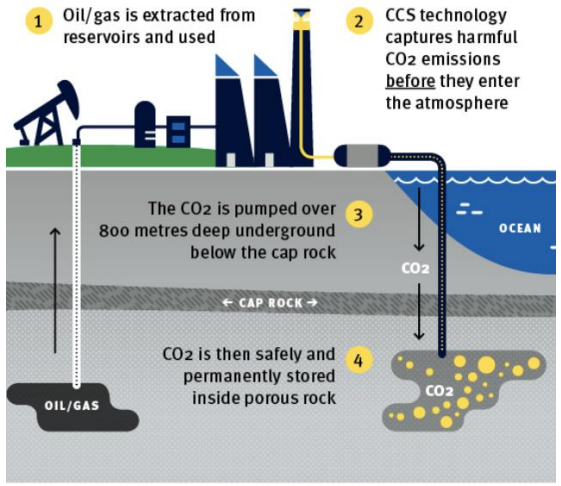
Blue=Hydro

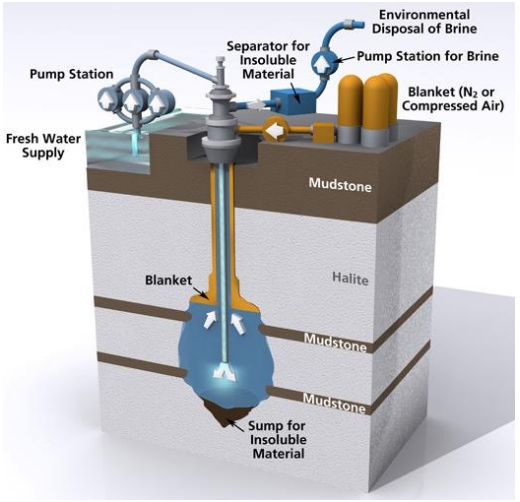
ExxonMobil Energy Outlook 2009

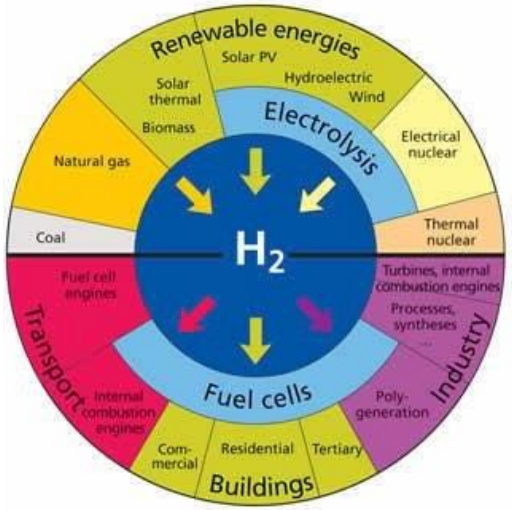
GRAND BALL GIVEN BY THE WHALES IN HONOR OF THE DISCOVERY OF THE OIL WELLS IN PENNSYLVANIA.

Energy Transition Has Several Key Technologies

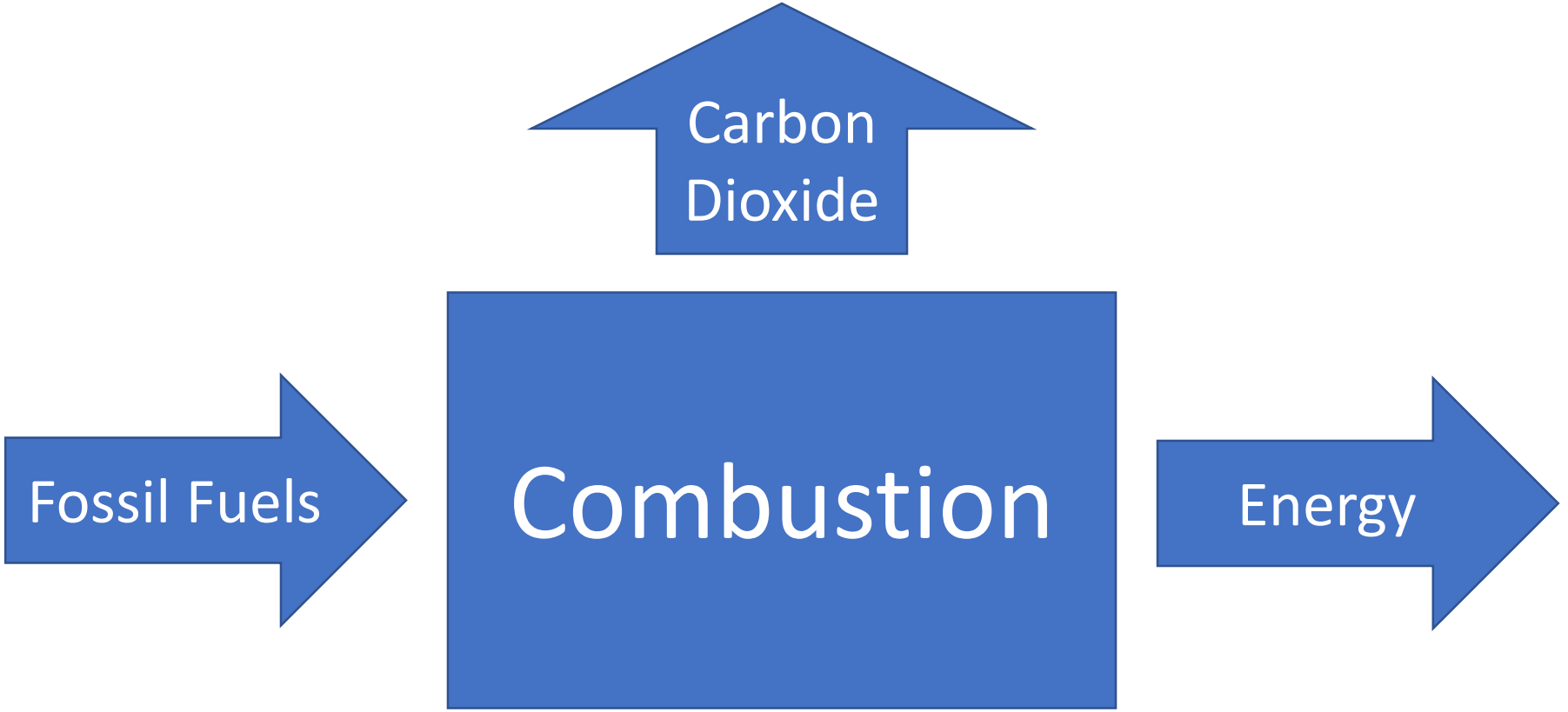
Carbon Capture & Storage	Energy Storage	Hydrogen Economy	Critical Minerals
• Gets CO_2 out of the atmosphere • Prolongs investments in current power plants	• Manages variable production of power from renewables ***and*** fossil generators • Network benefits	• Can be burned with natural gas • Transport fuel • Industrial uses	• Required for high tech manufacturing (e.g., solar panels, wind turbines, electronics, screens) • Complex to refine







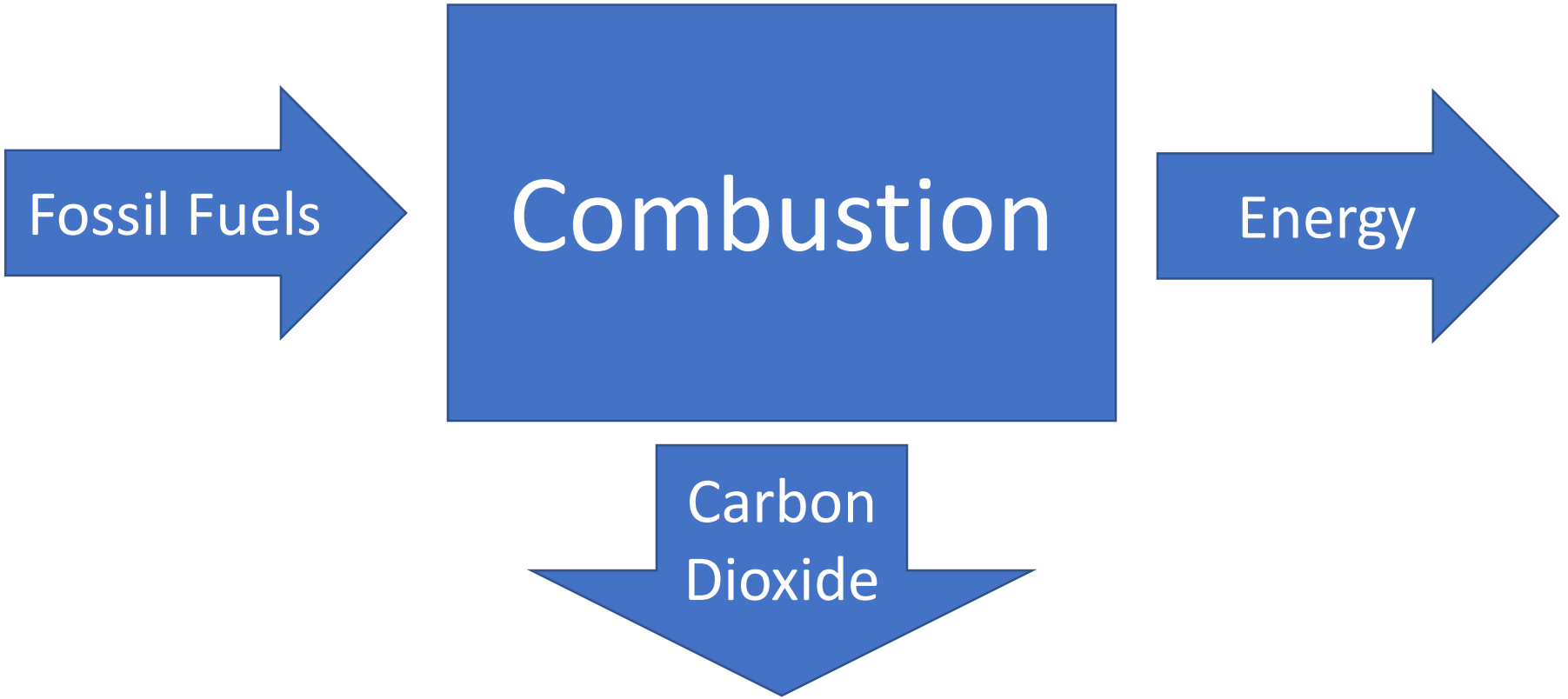
Current Fuel Cycle



Emits carbon to the atmosphere 😐

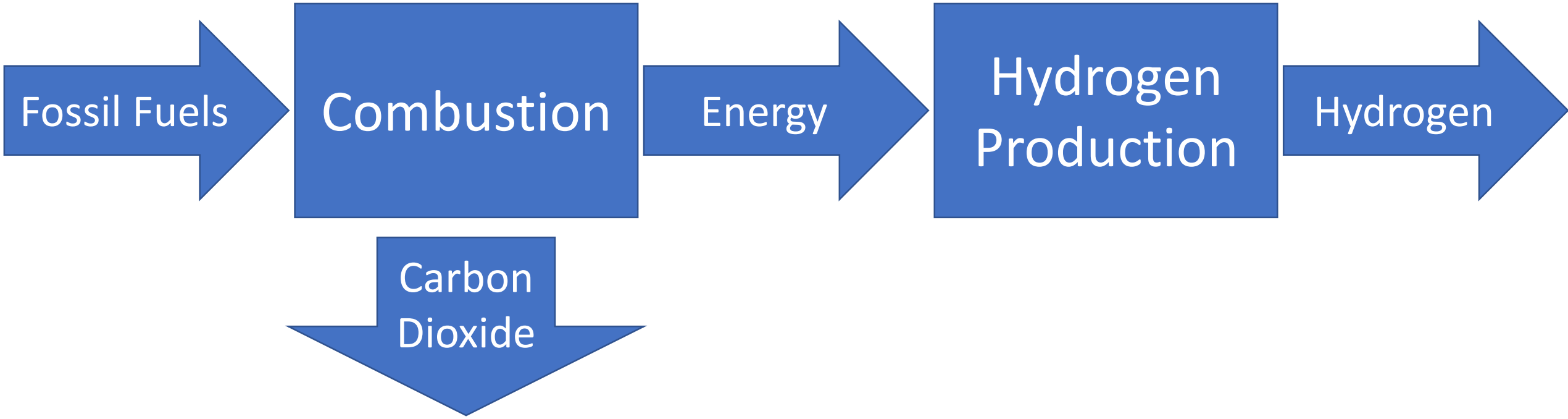
Carbon Capture System

Works for large sources of carbon emissions, like industrial facilities ☺

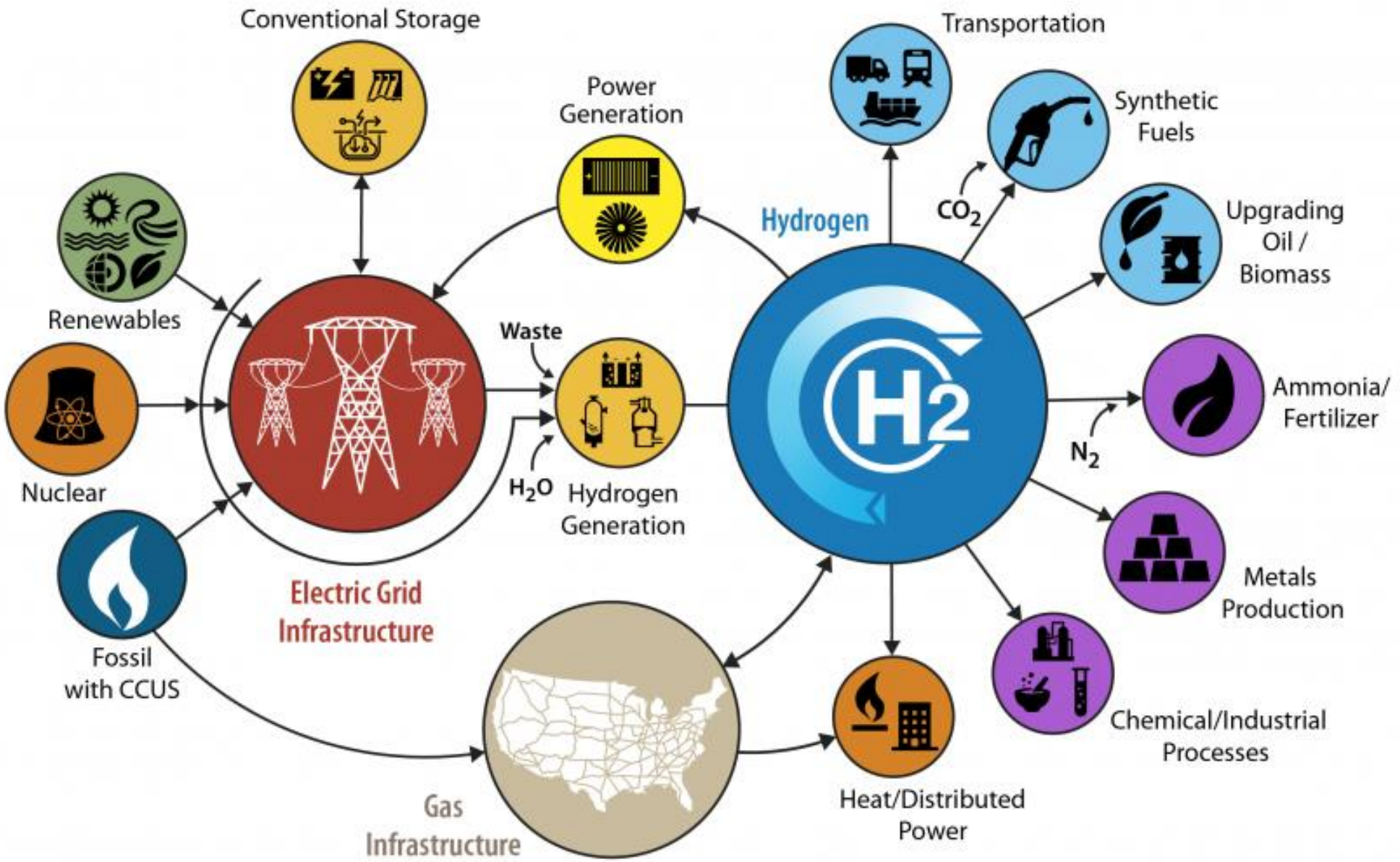


Hydrogen + Carbon Capture System

"Blue Hydrogen"

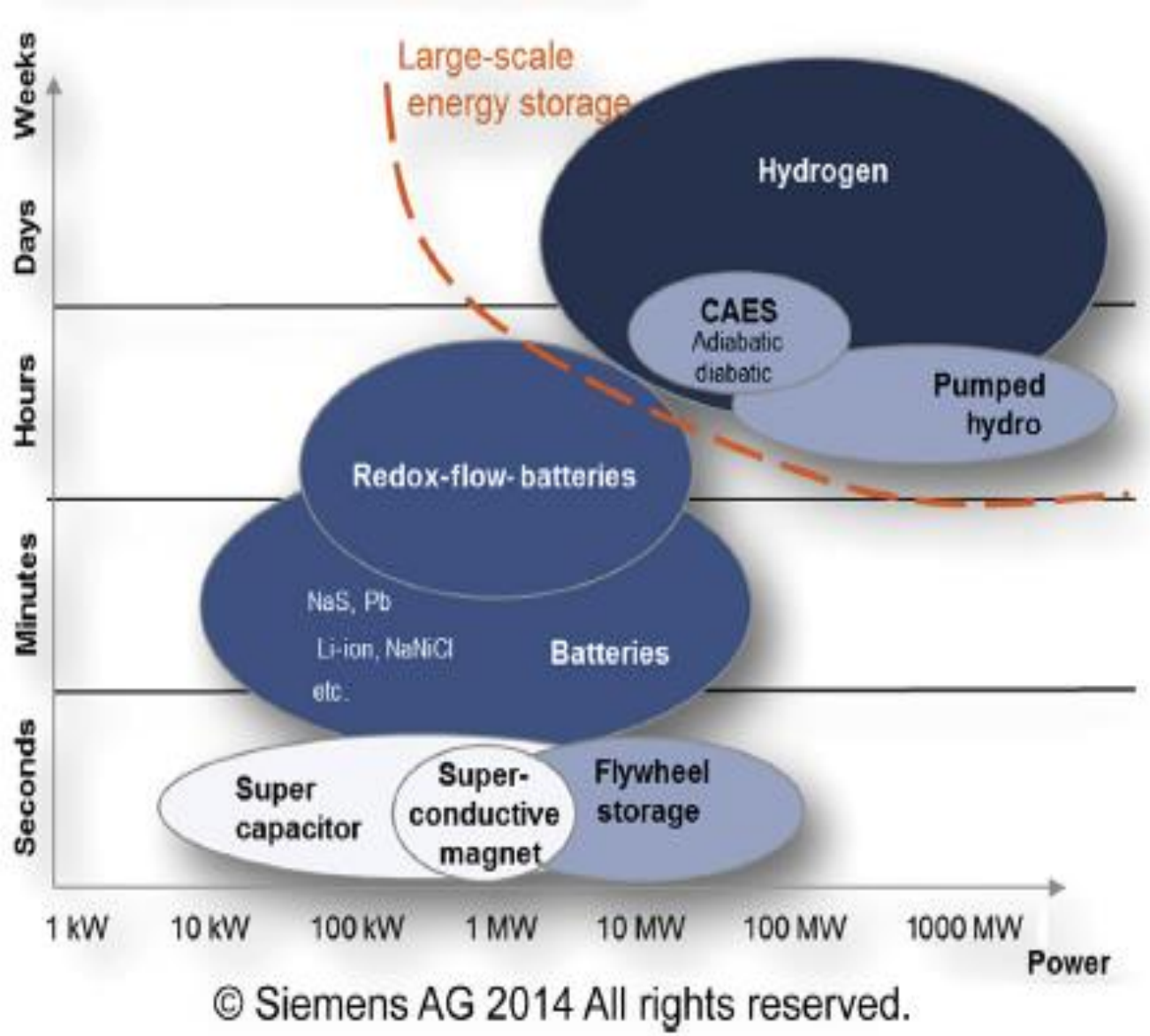


DOE Hydrogen Idea Map

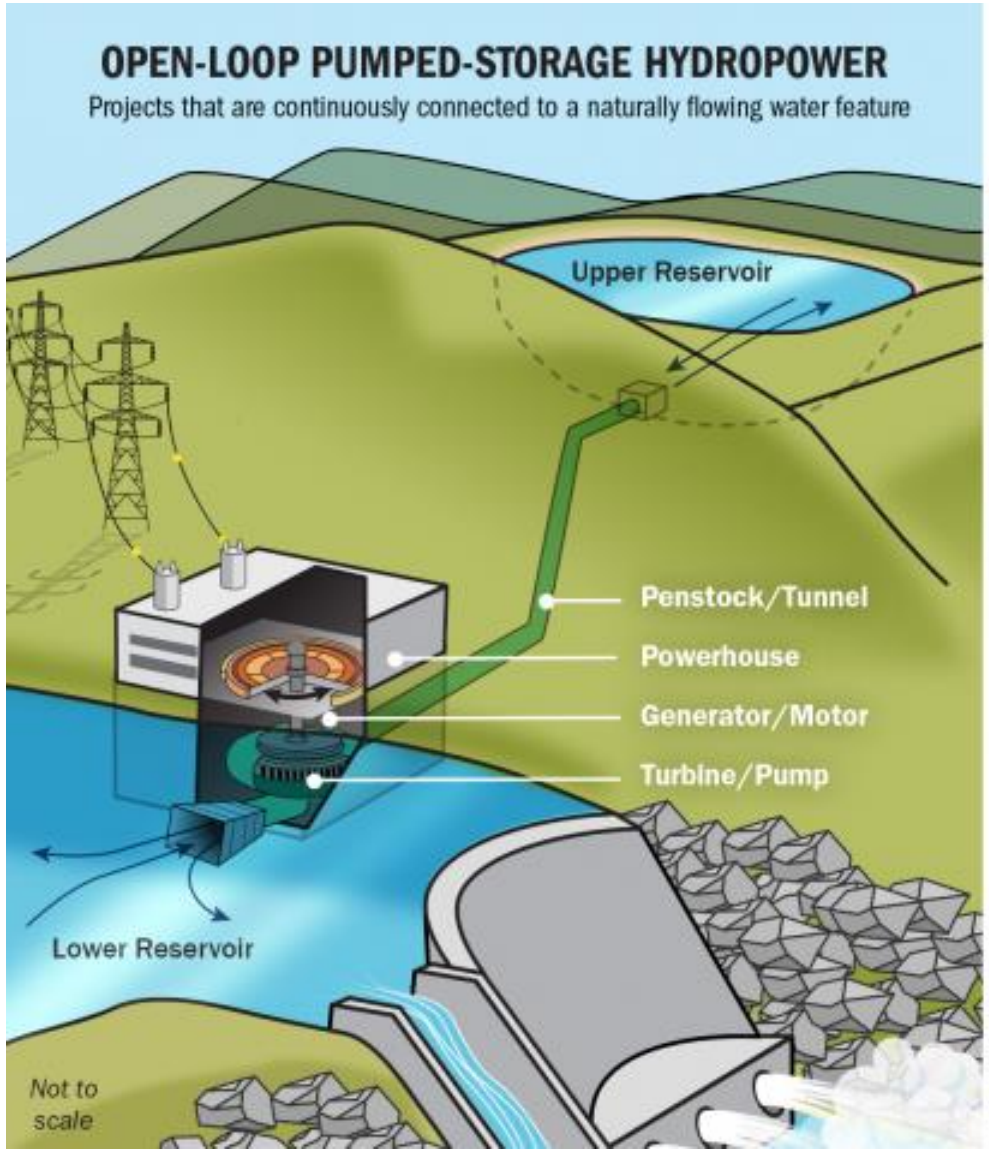


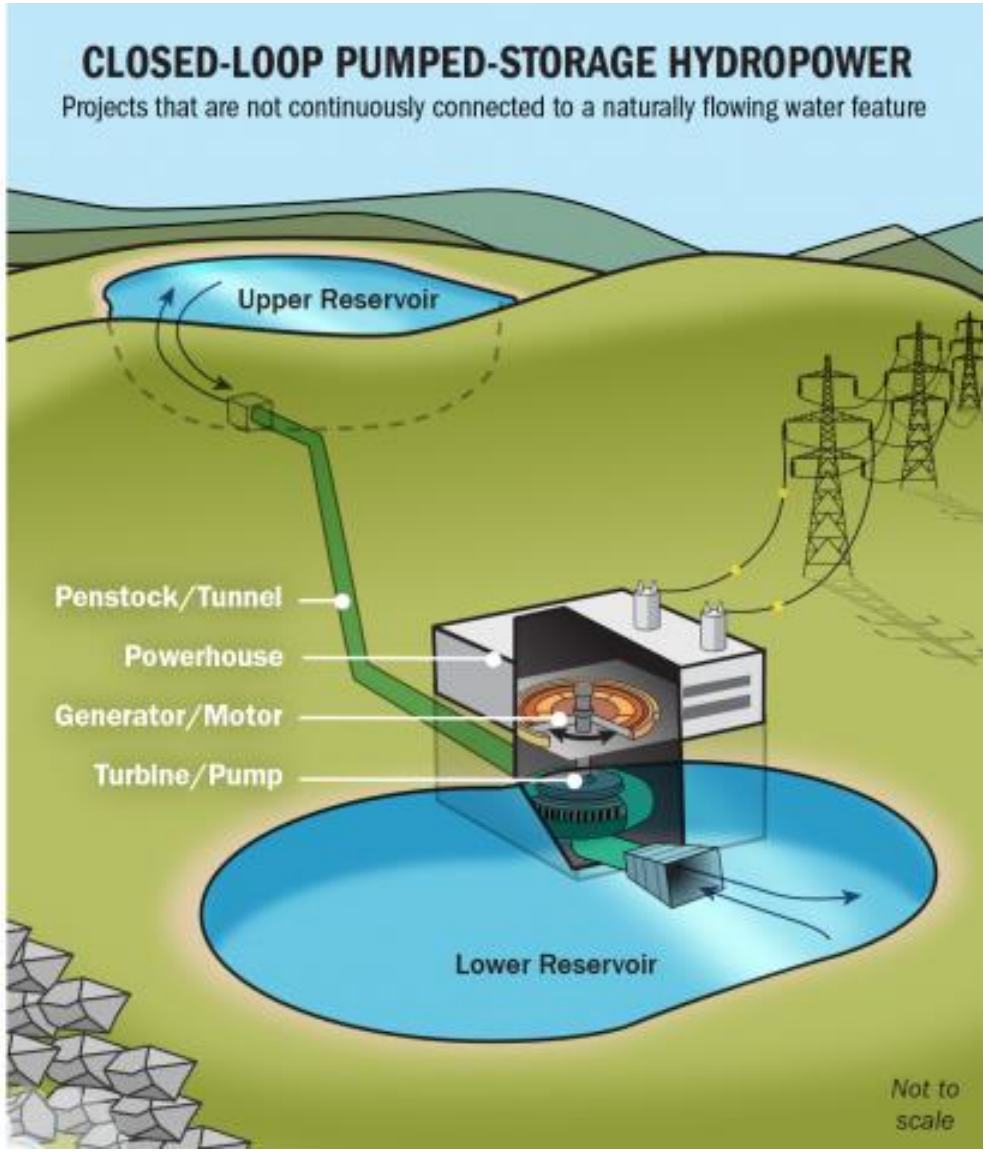
Energy Storage

- Energy storage is important
  - To prolong life of fossil fuel energy generators →CO_2 storage will manage emissions
  - To help with manage variable power from wind/solar
  - To ensure resiliency of energy system
- Cavern storage of hydrogen is the largest “battery” we can build
- Hydrogen storage also works on longer times scales (hours-weeks)



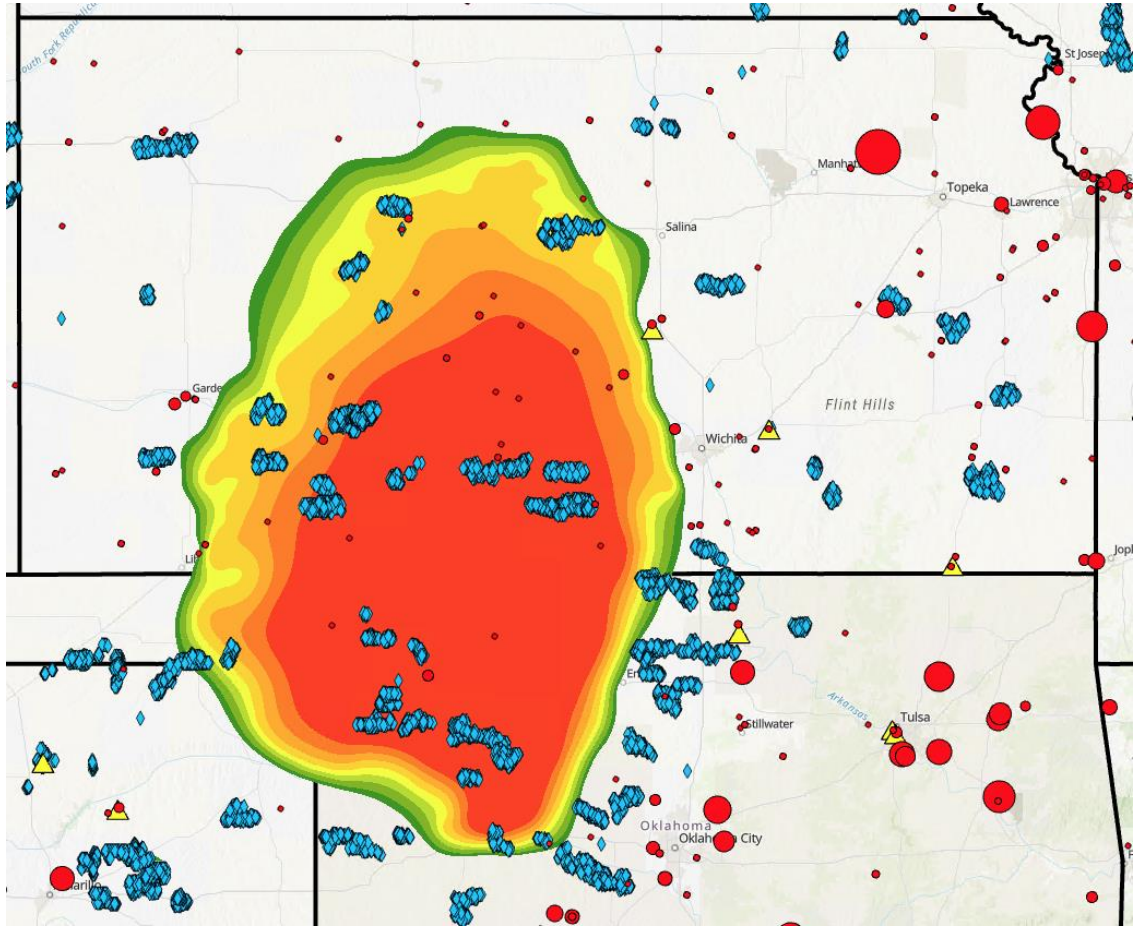
Pumped Storage Hydropower



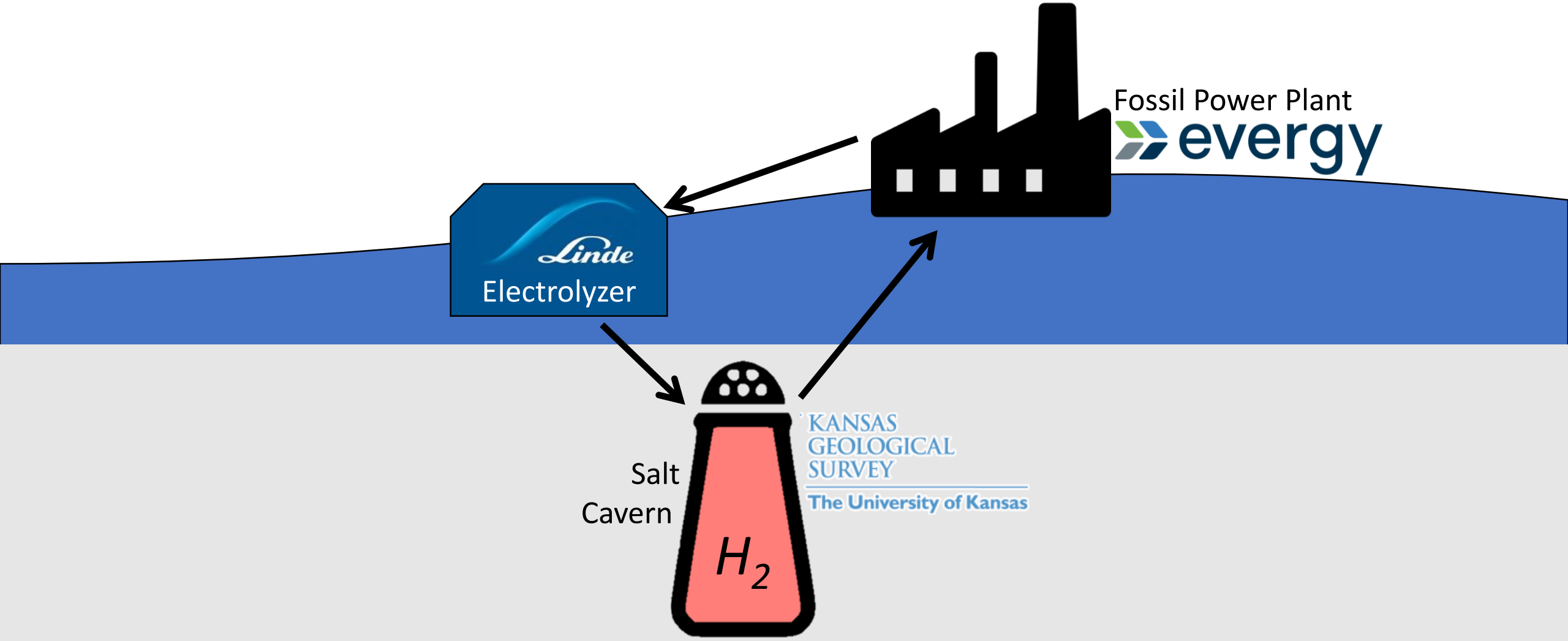


Kansas Hydrogen Summary

- Hydrogen is a useful energy storage medium ***and*** industrial feedstock
- Salt cavern storage of hydrogen is the the largest, longest term, commercial energy storage system
- Suitable salt exists in Kansas for commercial salt cavern storage of hydrogen



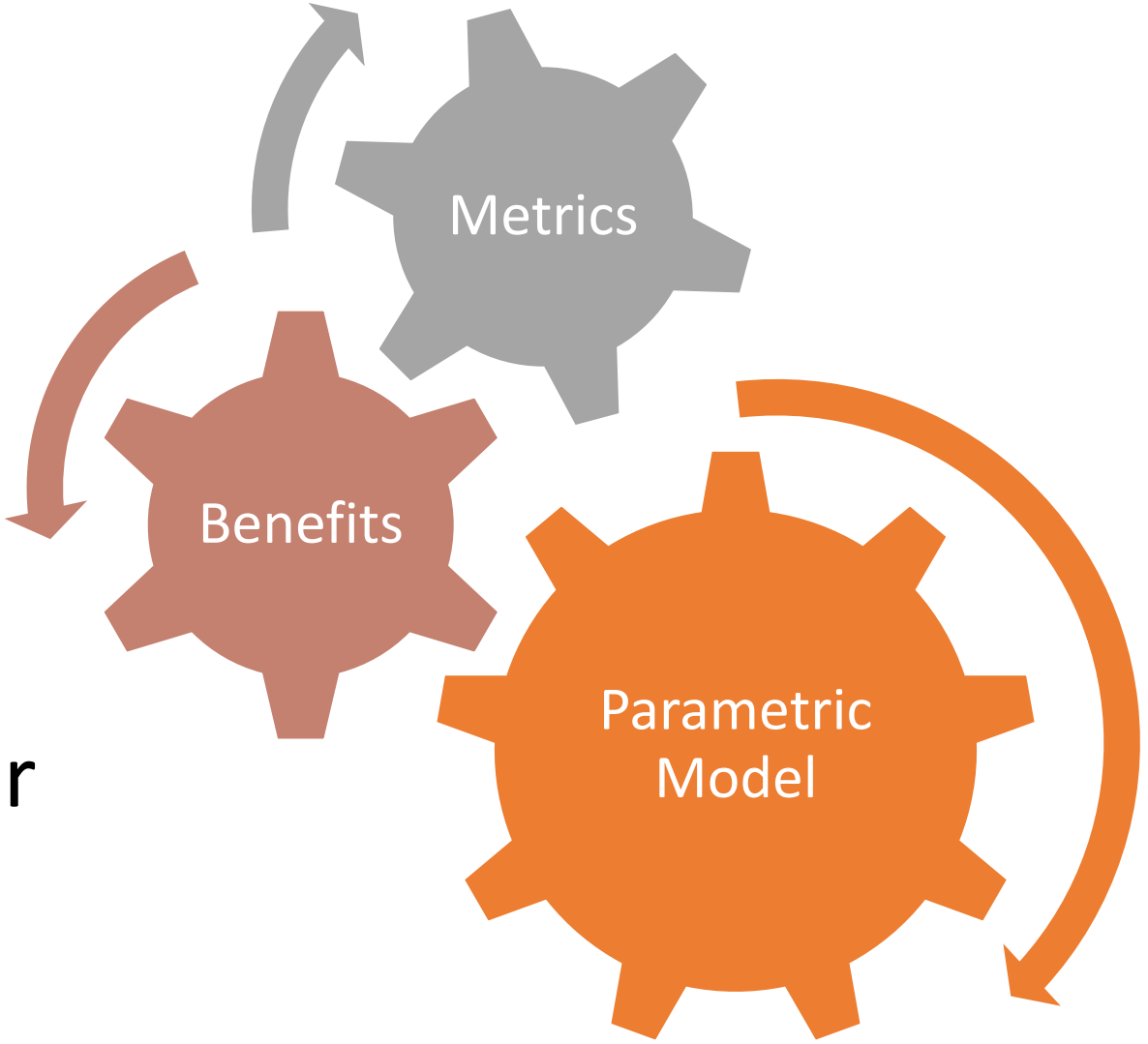
H-2-SALT Storing Hydrogen Under Kansas



DOE Award number DE-FE0032015 under DE-FOA-0002332

Techno-Economic Assessment

- Water use managed within current water rights
- $1.78 per kg H_2
- $43-45/MWh
- Near the DOE's target of $1/per kg H_2
  - Green Hydrogen is $3-5/kg H_2



Cavern Storage in Kansas

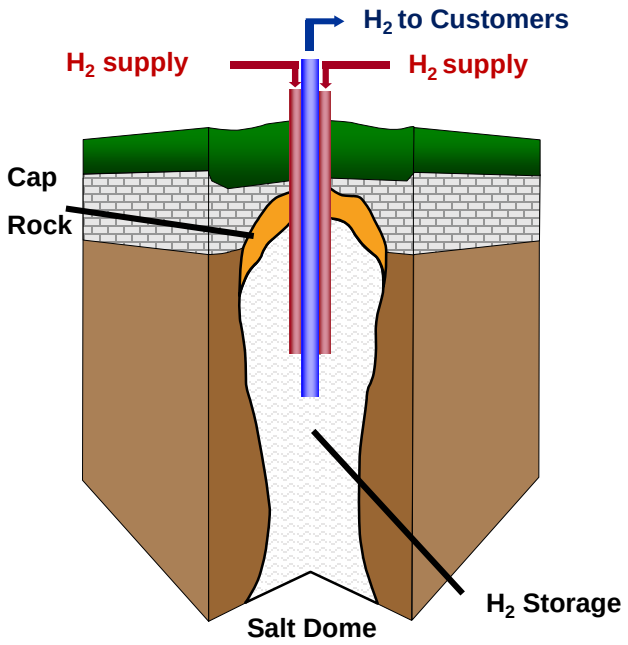
- ~750 total caverns
- ~350 active caverns
- 73 million barrels

Kansas Department of Health and Environment

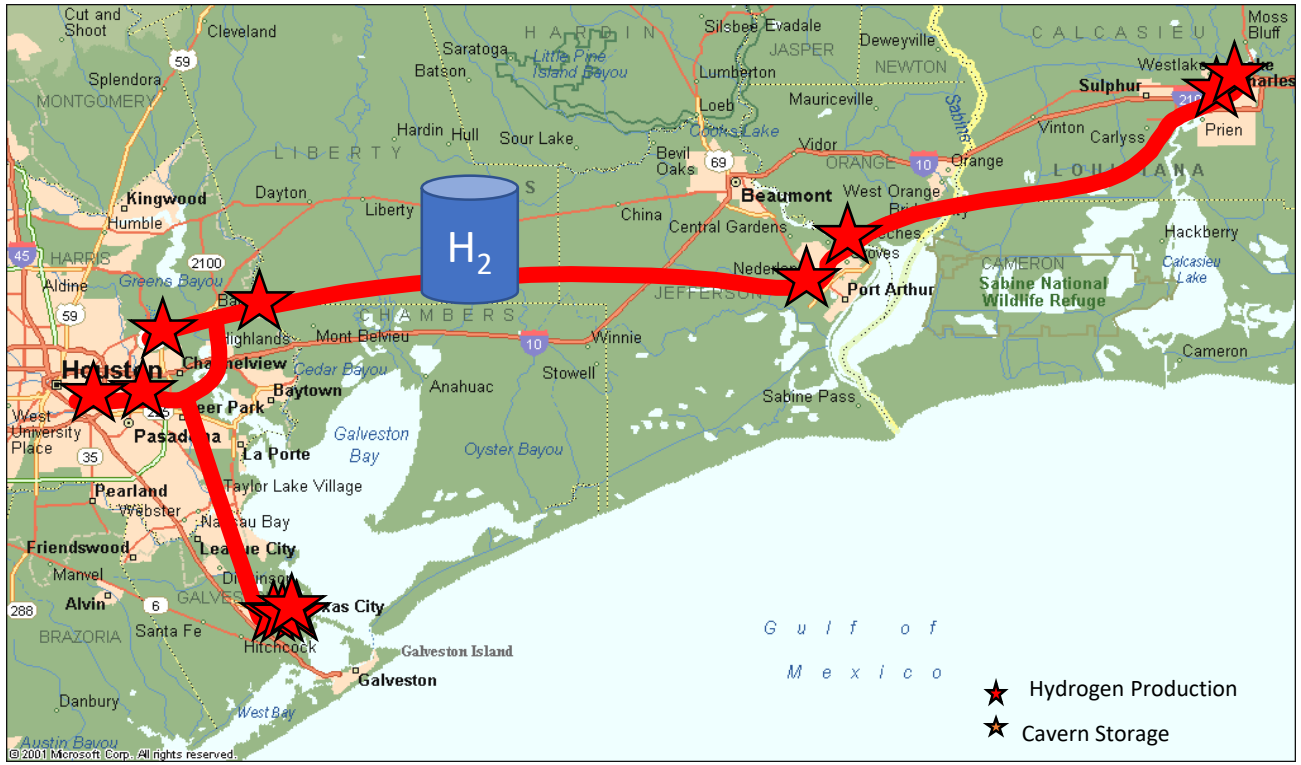
KDHE, 2019

Linde Runs H_2 Storage Network in Texas

- Salt cavern storage with 40 million m^3 working capacity (1.4 Bcf)
- 350-mile pipeline from Texas City, TX, to Lake Charles, LA
- Connects 50 customers
- 600 mscf/d rate



Gulf Coast Hydrogen Pipeline



A Kansas Hydrogen Hub

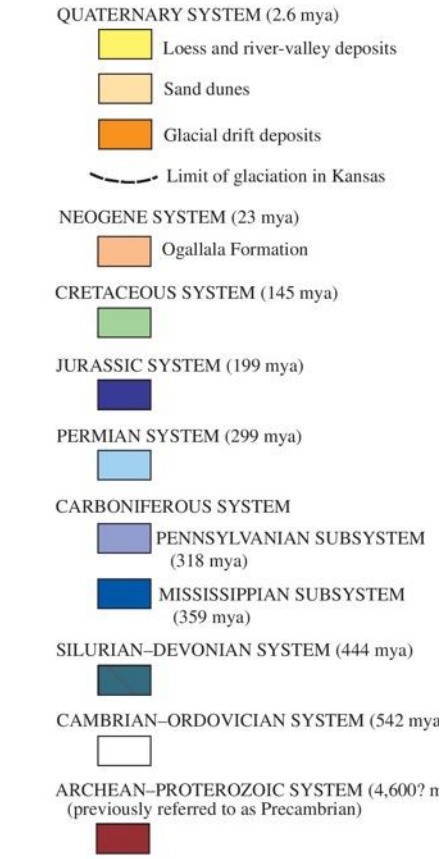
Diversified Power Generation in Kansas

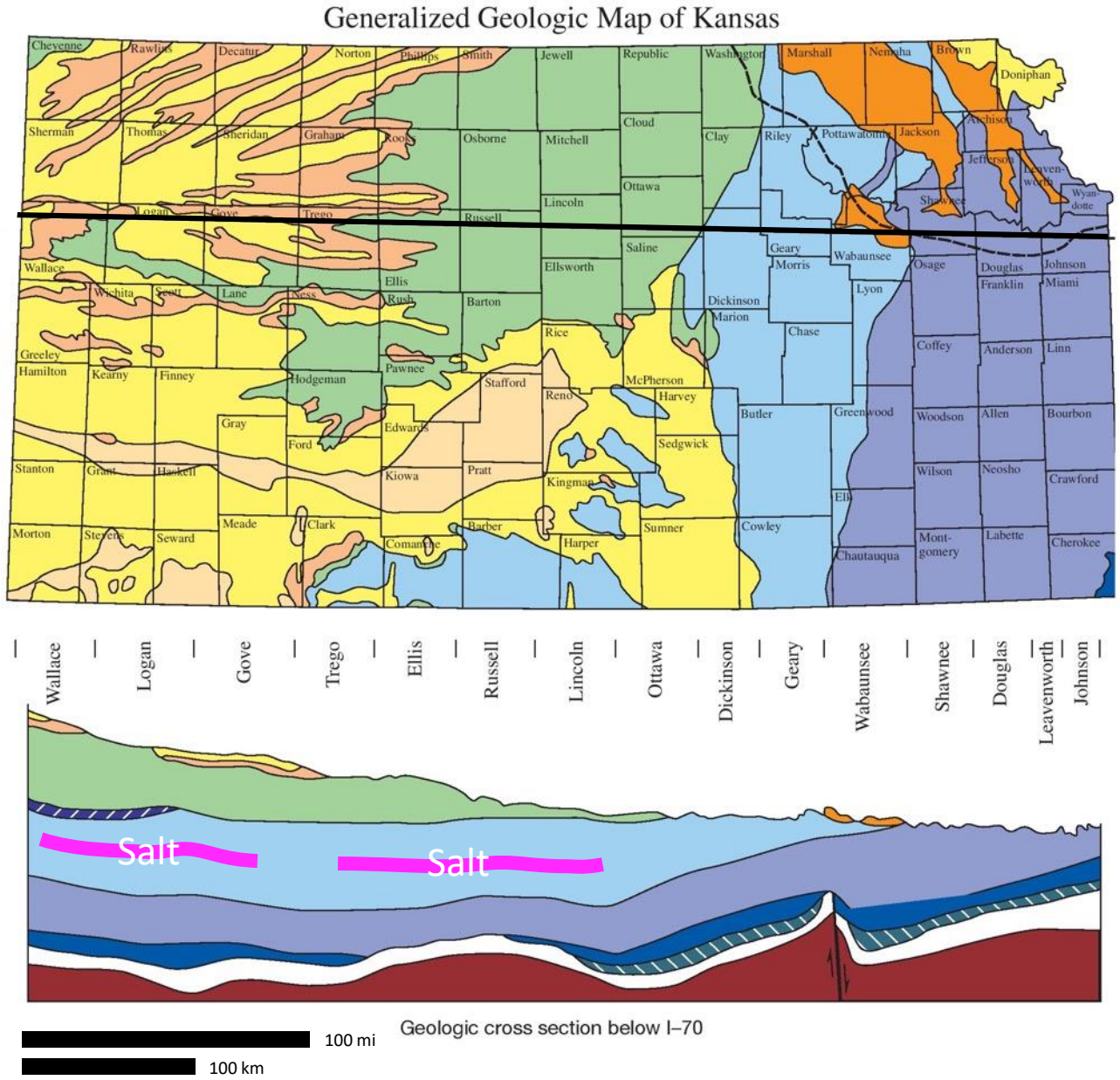
Energy

- Kansas has diversified portfolio of power sources – nuclear, coal, natural gas, wind, solar
- 44% of all KS electricity comes from wind and solar
  - 4th largest wind power generator in the nation (2021 ~24 TWh)
  - 2nd largest in the US – wind as a percentage of total)
  - Wind & solar production capacity is growing in all quadrants of the state
  - $14B in CAPEX in new wind projects
  - 3,700 active wind turbines
  - 12,000 direct and indirect jobs created

Permian Bedded Salt Occurrences

- Salt occurs naturally in Permian beds
- Physical properties make it an excellent seal

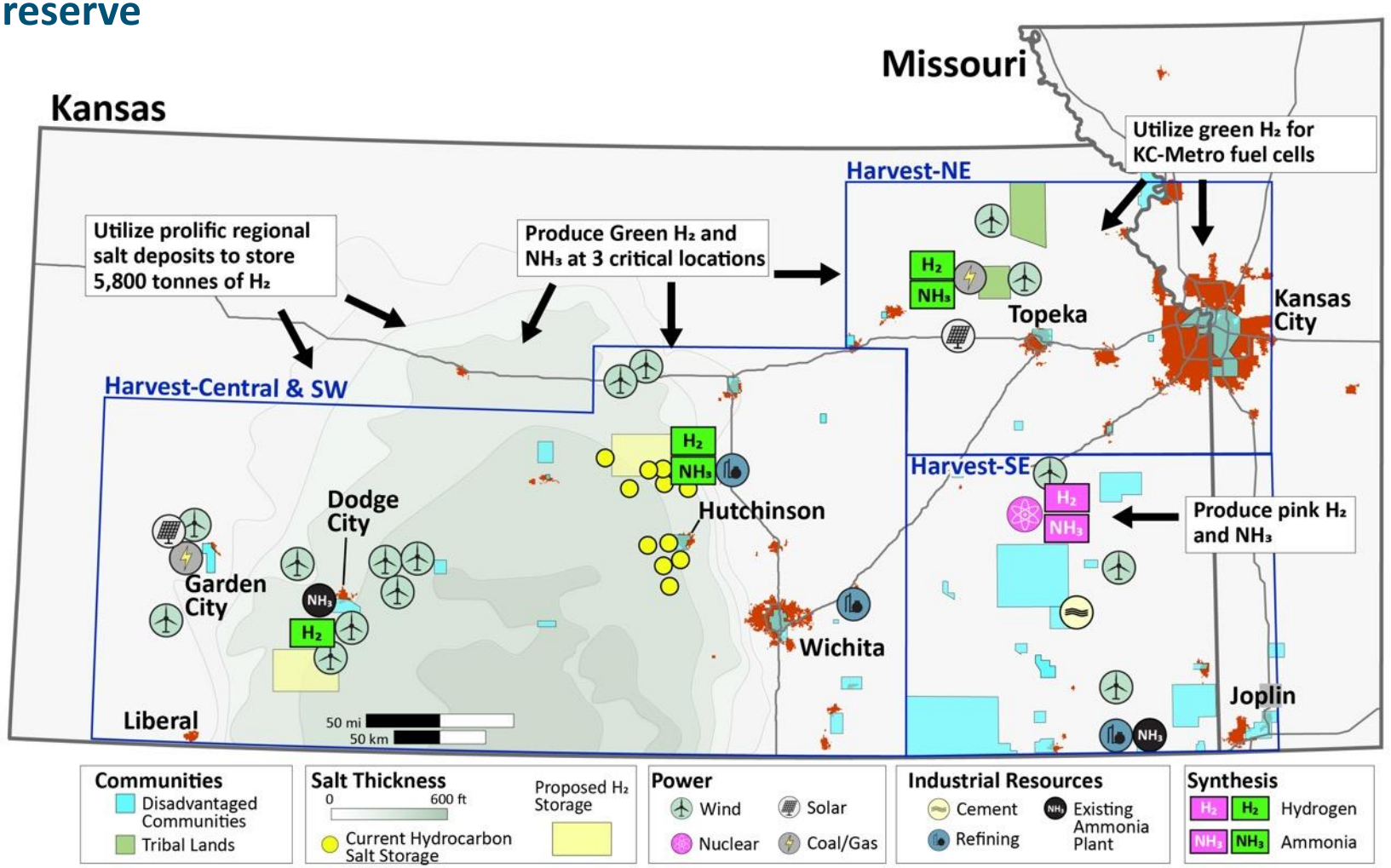




- Salt in 6” core
- Low Porosity & permeability

HARVEST Hub Concept

- **A partnership between major power producers, industries, & leading research institutions to develop carbon-free hydrogen**
- **Bring federal matching grant support to develop a strategic hydrogen reserve**



- Will utilize excess wind, solar, and nuclear power to produce low-cost H_2 and NH_3
- Three regional focus areas; four production sites
- Production Rates:
  - H_2 = 250-300 T/day (100 kT/yr)
  - NH_3 >500 kT/yr
- Develop >40 storage caverns in multiple locations; store an initial 5,500 – 6,000 T H_2
- Community Benefits
  - New industries
  - Quality jobs
  - Lower cost ammonia
- Environmental Impact
  - Reduce CO_2 by 1.2 MM T/yr

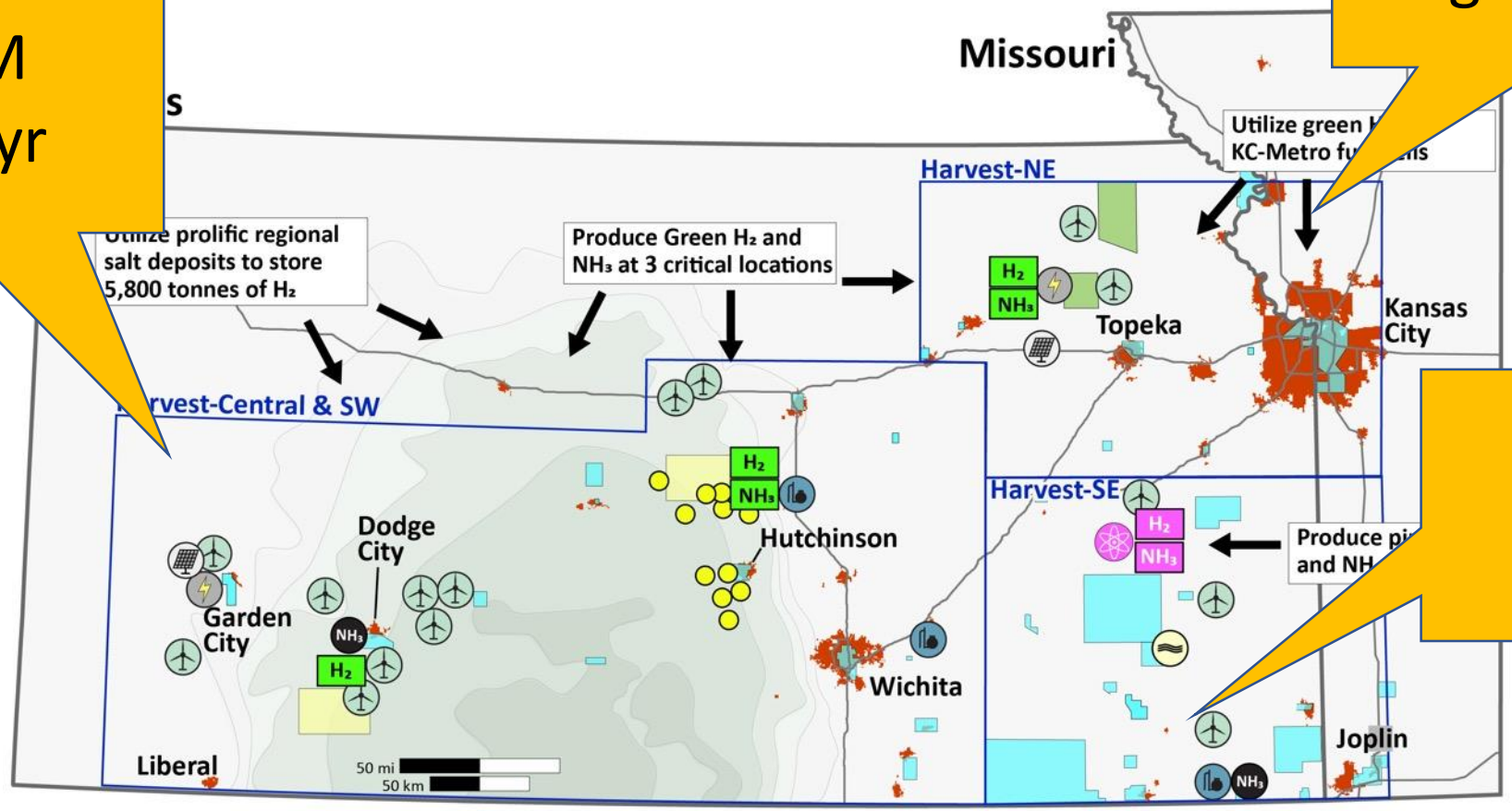
H2 HARVEST HYDROGEN

HARVEST Hub water use for 100 tons H_2/day

150 MM gallons/yr

490 MM gallons/yr

410 MM gallons/yr



DOE-Created Strategic Petroleum Reserve

U.S. to Release Millions More Barrels of Oil to Contain Gas Prices

The Department of Energy will release 15 million more barrels from the Strategic Petroleum Reserve and plans additional releases this winter.

NY Times

Strategic Hydrogen Reserve?

Strategic Ammonia Reserve?

DOE Office of Fossil Energy

Entity Composition & Sponsors

Advanced Power Alliance

Research Institutions

- Kansas Geological Survey
- Center for Environmentally Beneficial Catalysis
- University of Kansas
- Sandia National Lab.
- Idaho National Laboratory
- Kansas State University
- Salt Mining Research Institute
- Wichita State University

Sponsors

- Department Of Commerce
- Kauffman Foundation

Industry Partners

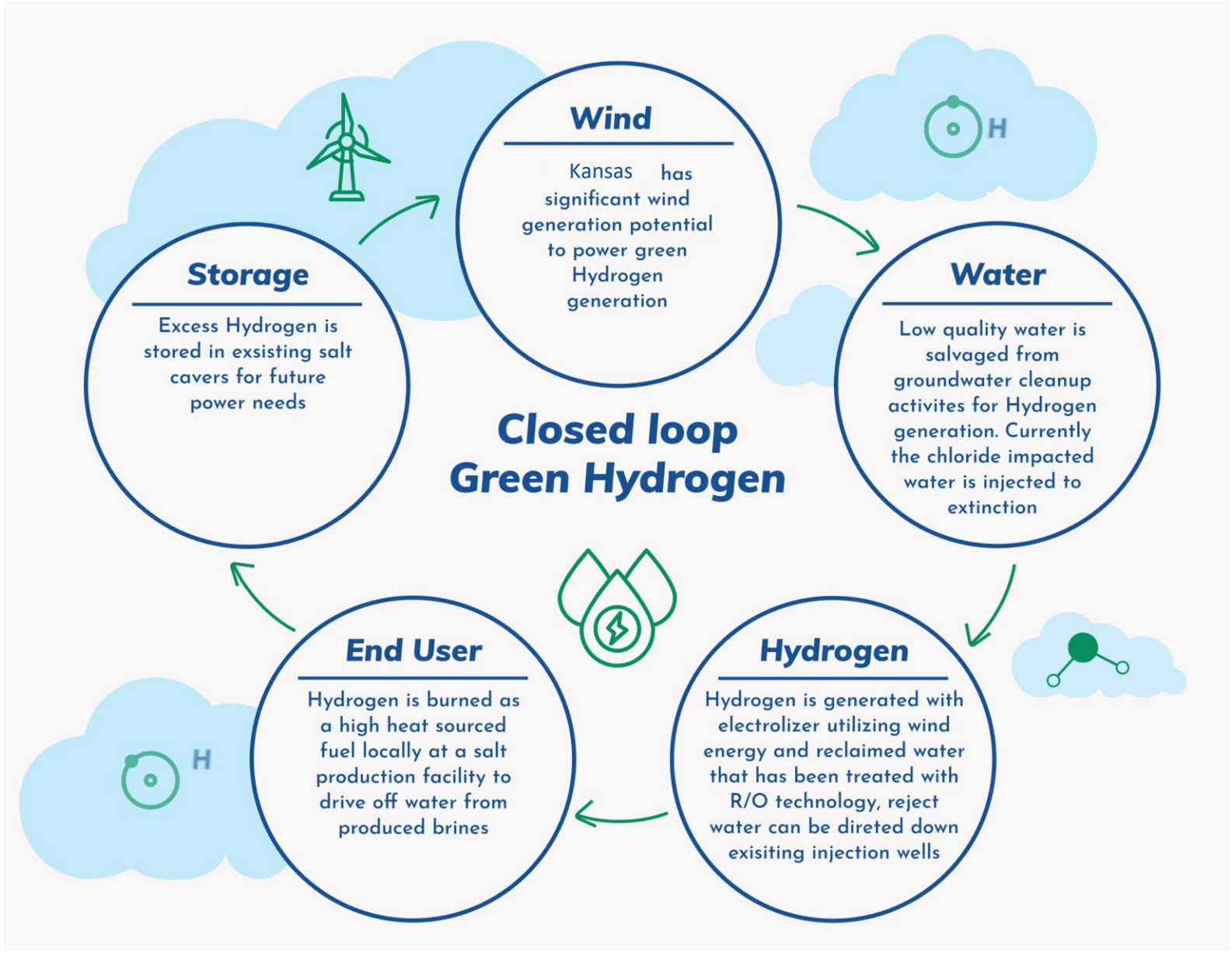
- Evergy
- Enel
- Nextera
- Black & Veatch

Continuing Conversations

- Koch
- Compass Minerals
- Tallgrass
- Monarch
- Ash Grove

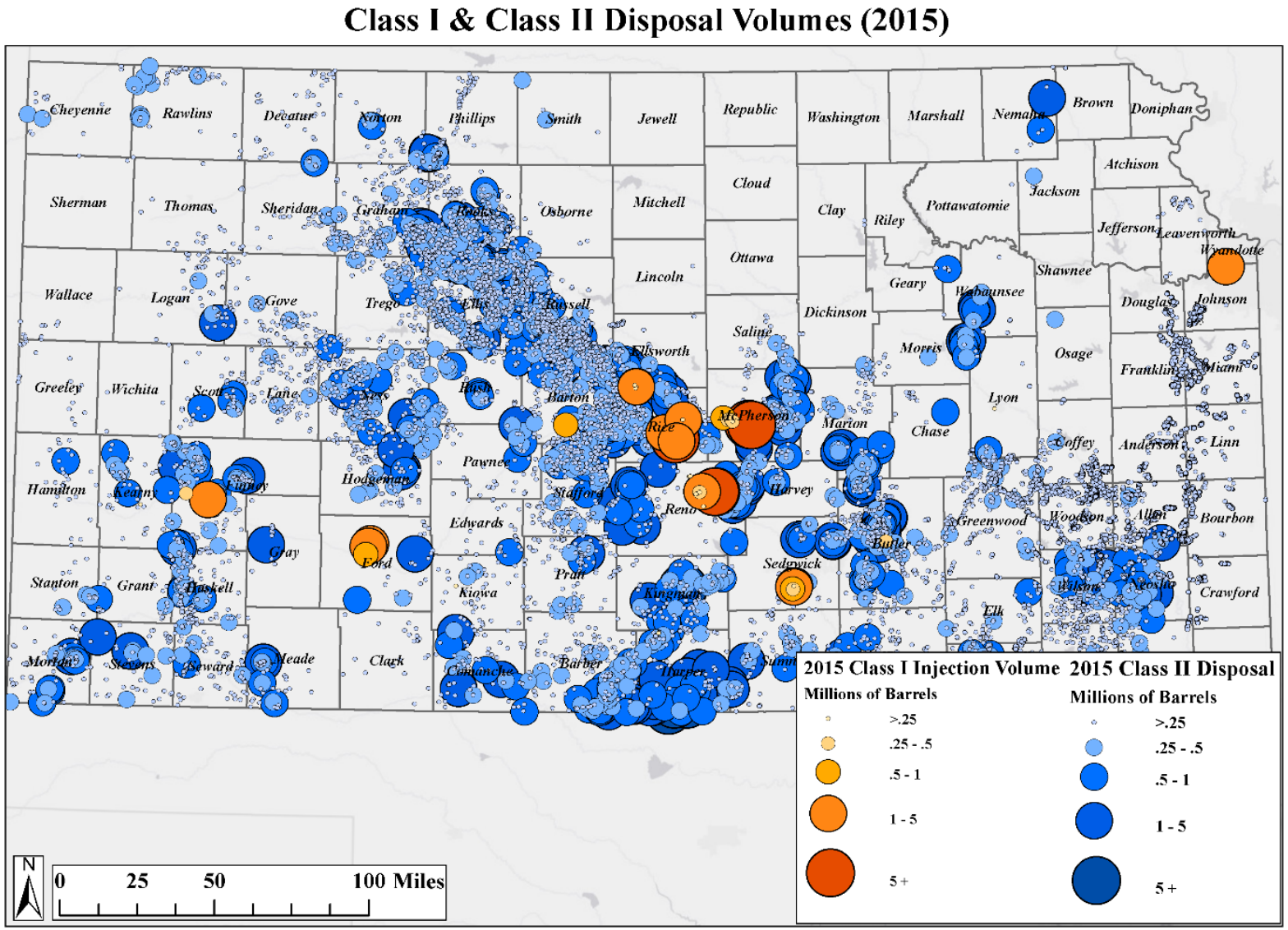
H2 HARVEST HYDROGEN

A Future Energy System in Kansas



Graphic:
Carrie Ridley

Produced water re-injection



Map printed 3/1/2017

Sources: Kansas Department of Health and Environment, ESRI, USGS, Kansas Corporation Commission, Kansas Geological Survey

Summary

- Evolution away from emitting carbon dioxide underway
- Increased deployment of renewable energy requires more energy storage
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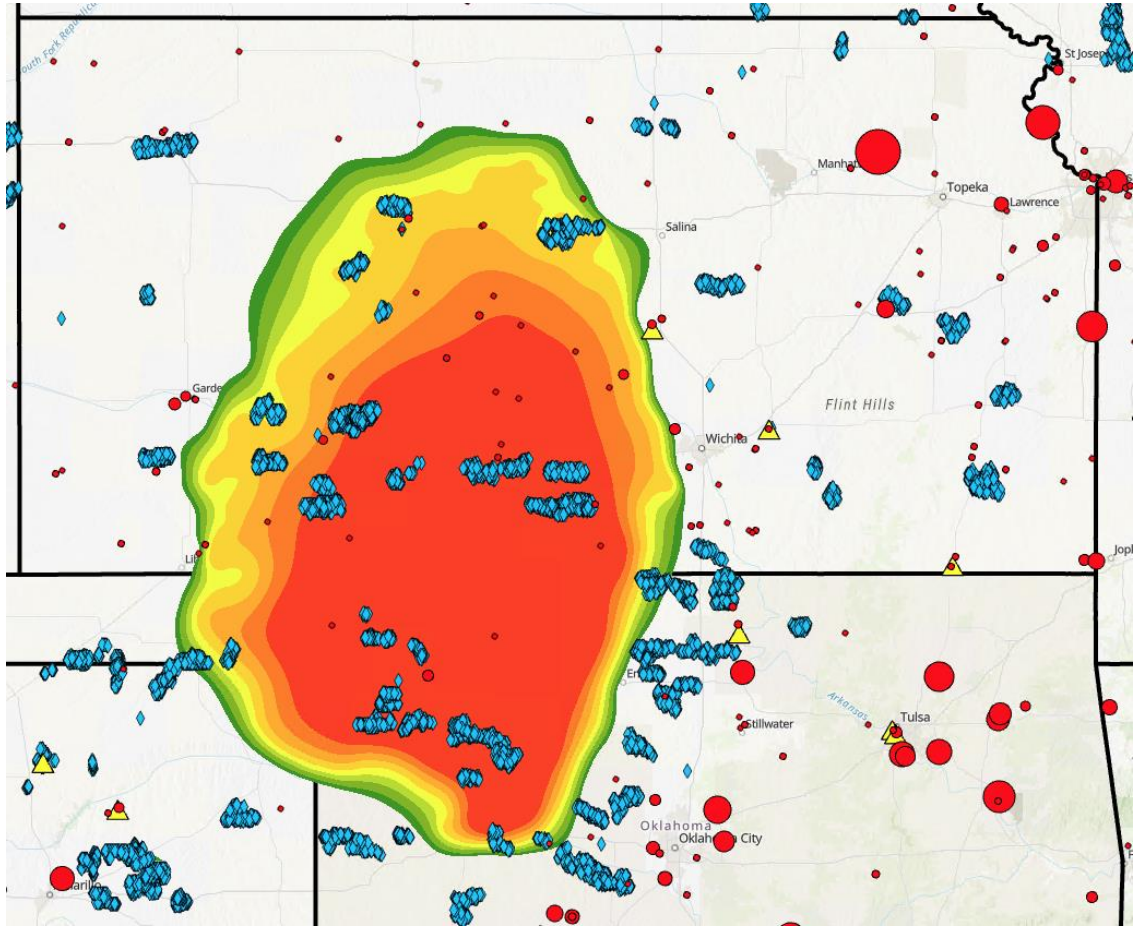
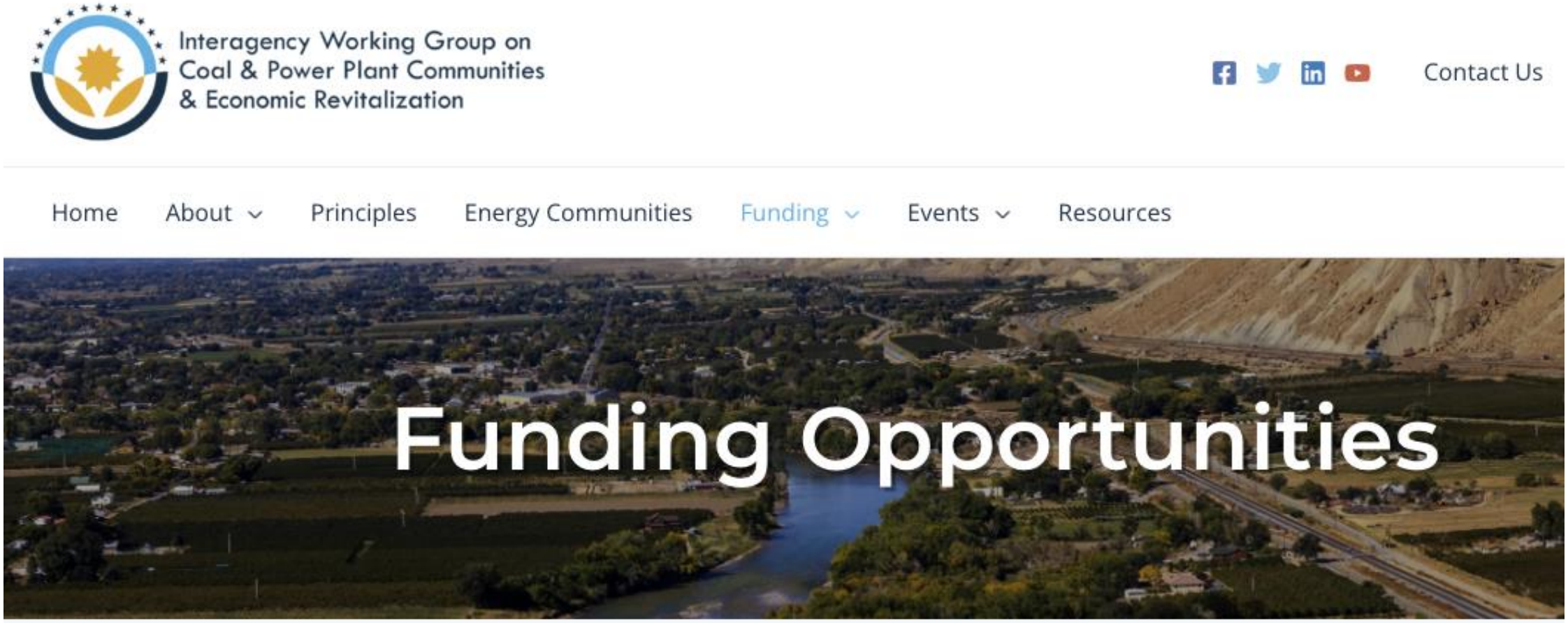
- Creativity during this evolution can free us from entrenched views on water in Kansas



EnergyCommunities.gov



Backup

This won't be easy, *but luckily Kansans are on it!*

The future isn't that far away, #1

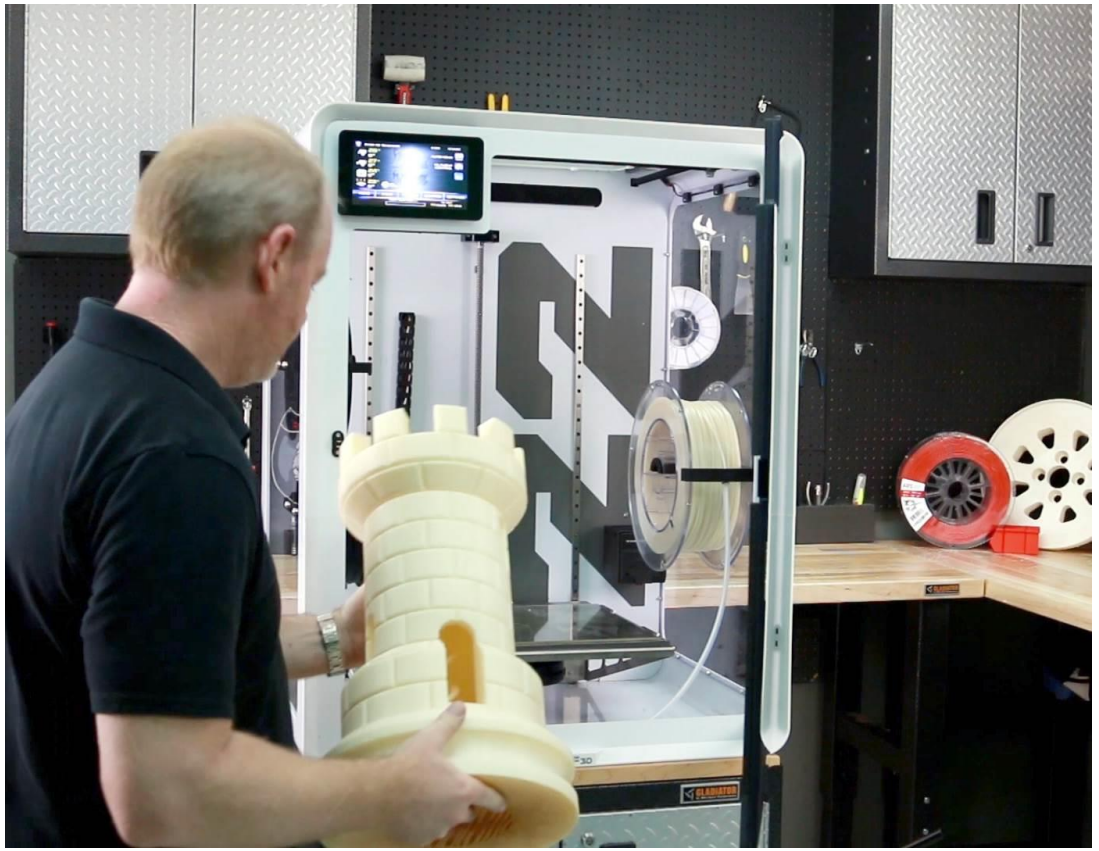
24th Century

21st Century

The future isn't that far away, #2

24th Century

21st Century



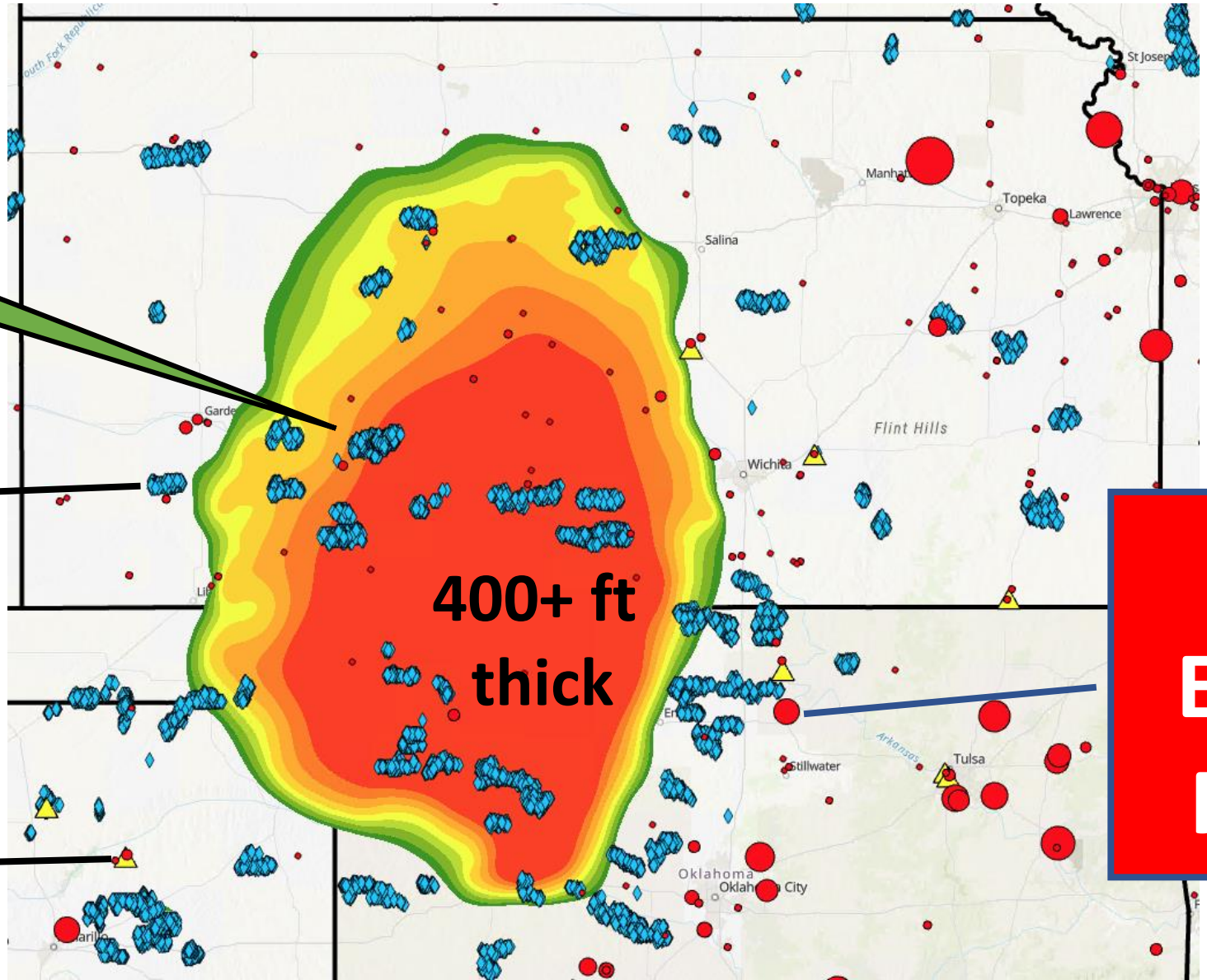
We know the energy evolution occurs!

Geography of Storage in Kansas

Hutchinson Salt Thickness

Wind Turbines

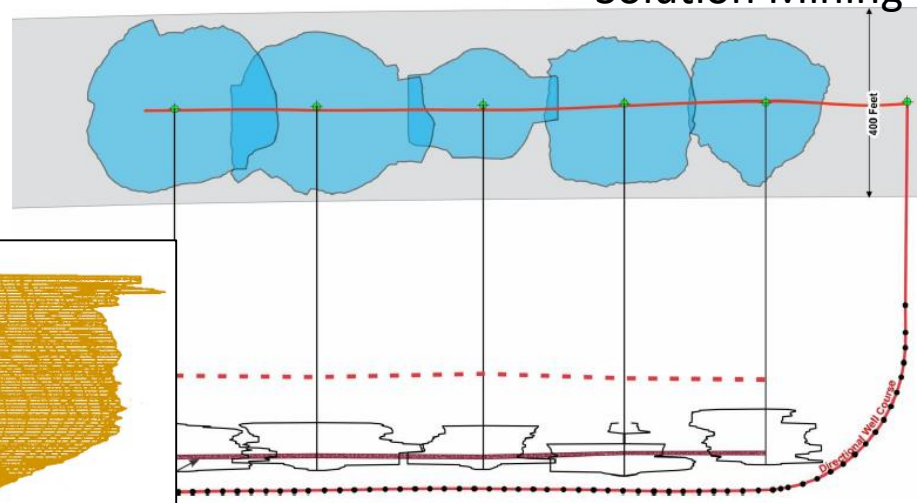
Refineries



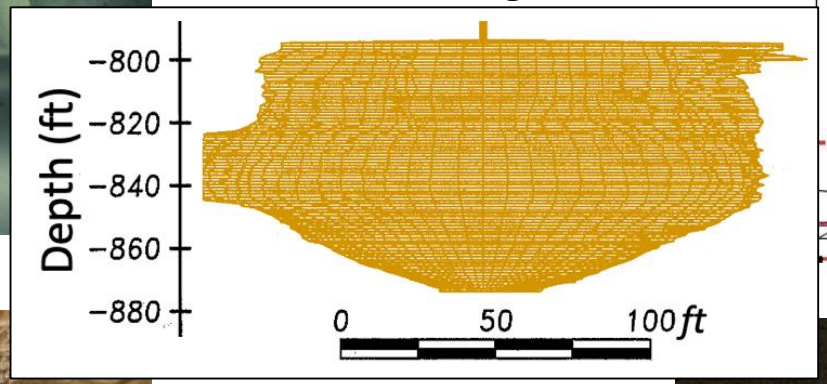
Fossil Energy Plants

Kansas has diverse a salt industry

Solution Mining

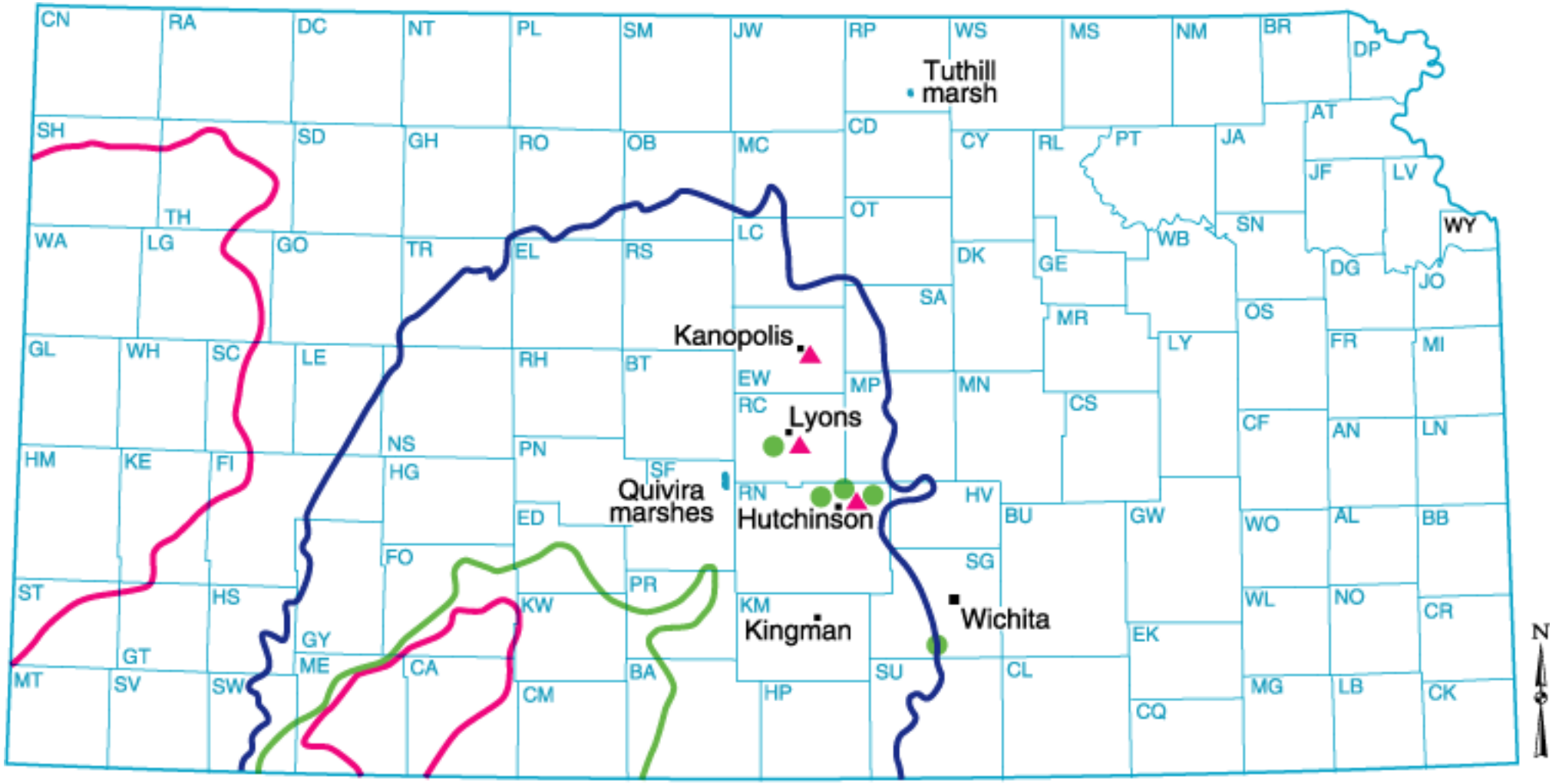


Cavern Storage



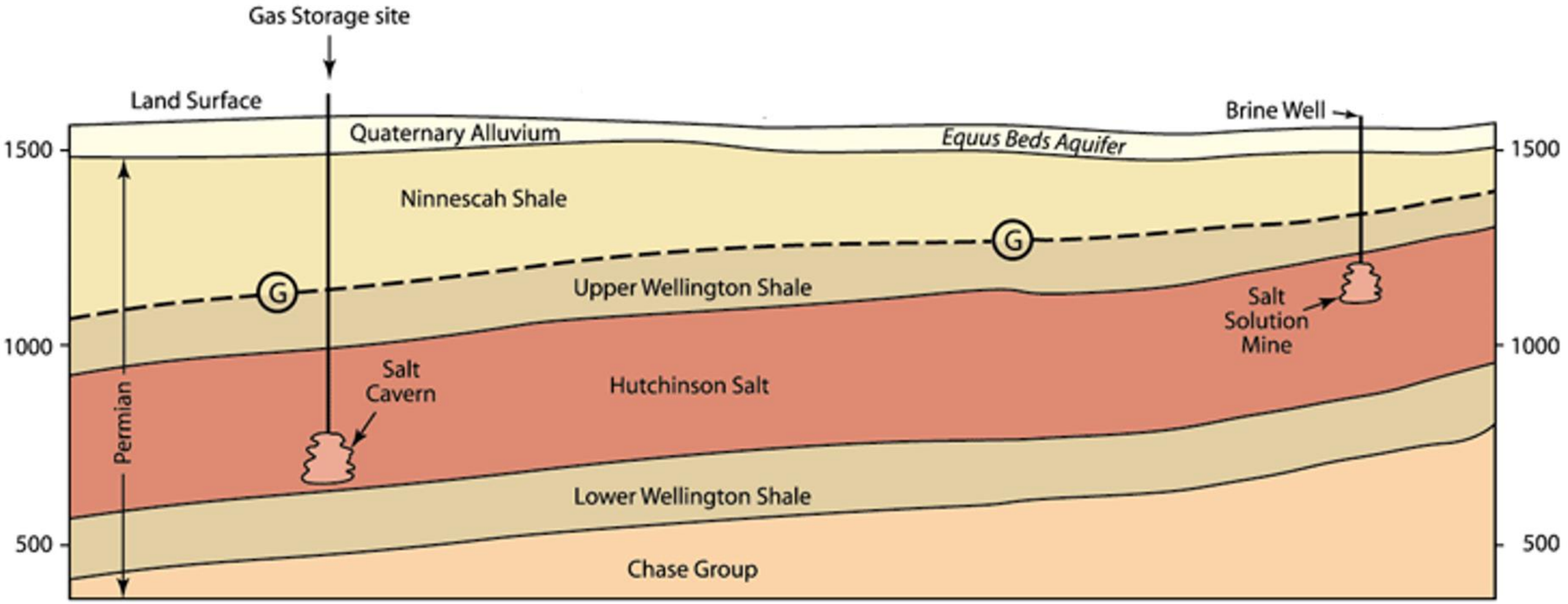
June 26

Kansas Has 3 Salt Beds

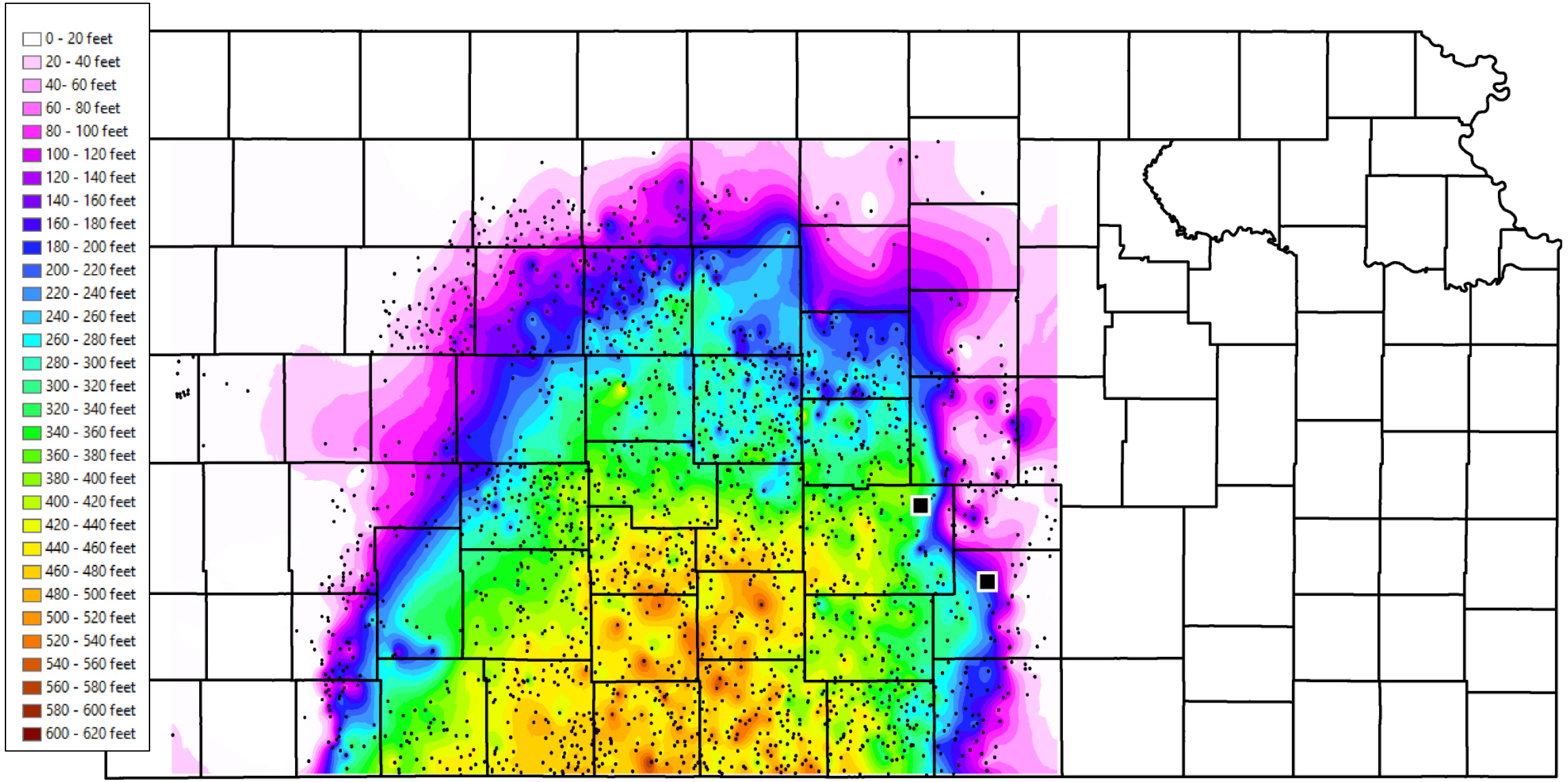


Sawin and Buchanan, 2003

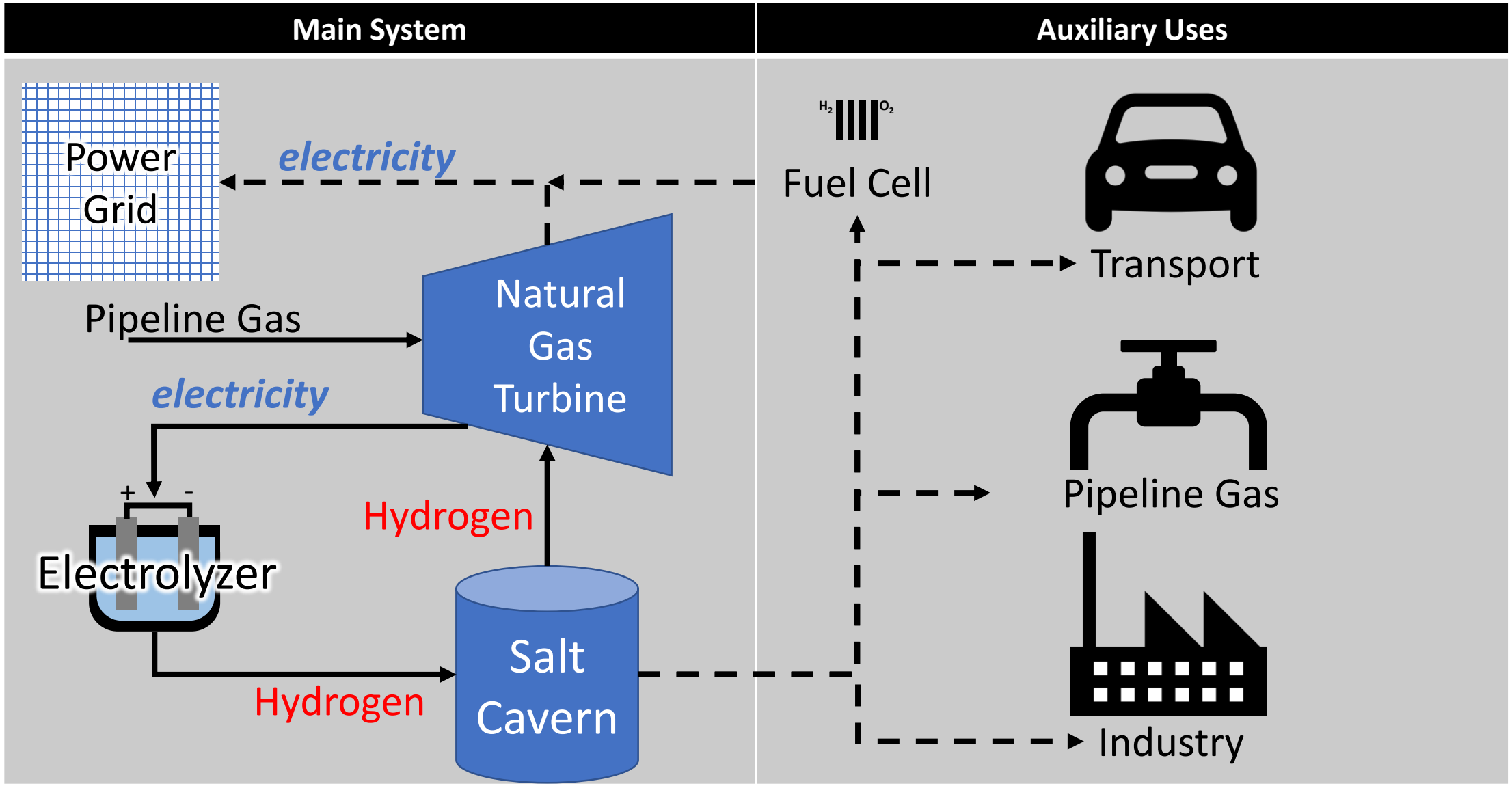
Cross-section through the Hutch Salt



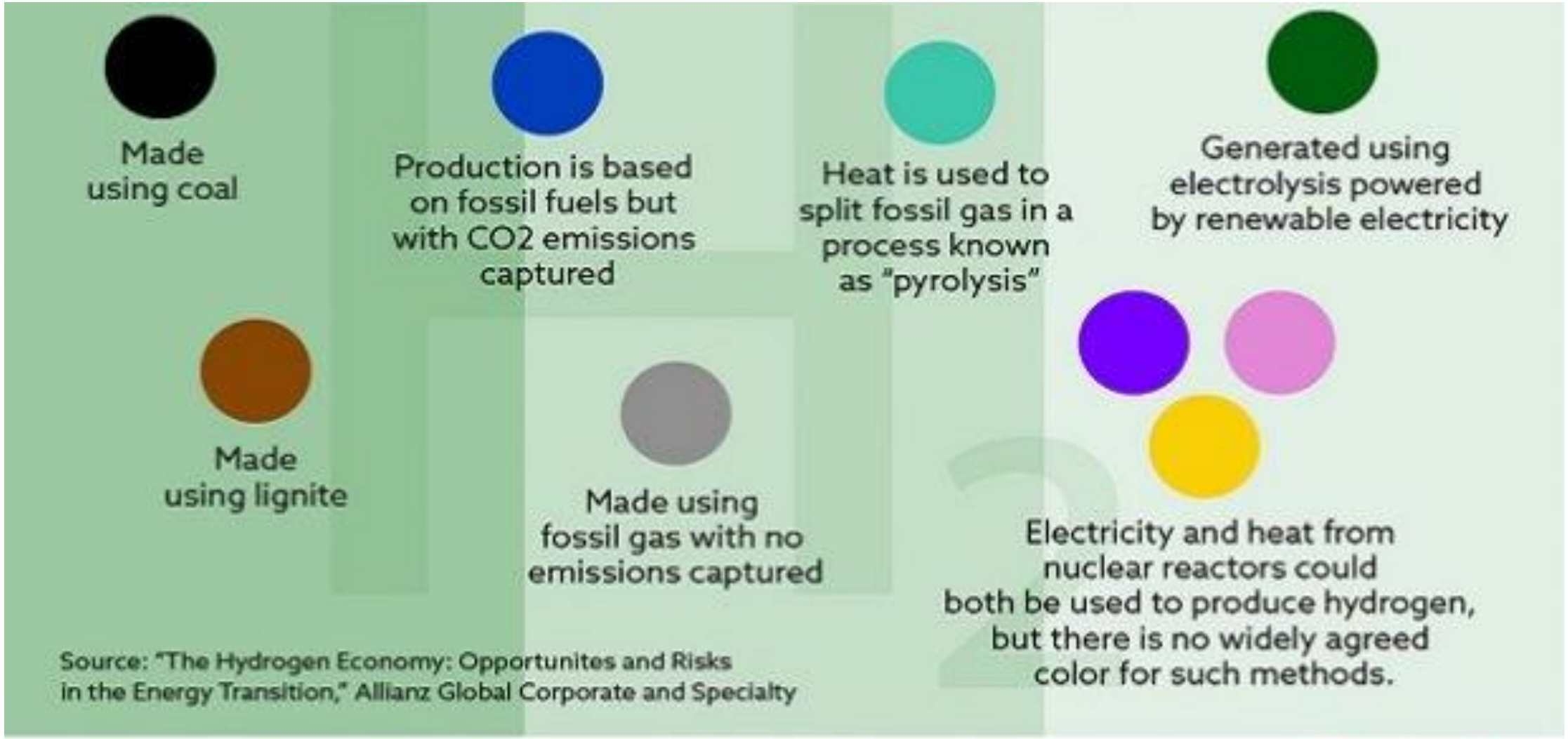
Thickness of Hutchinson Salt Map



H-2-SALT System Diagram



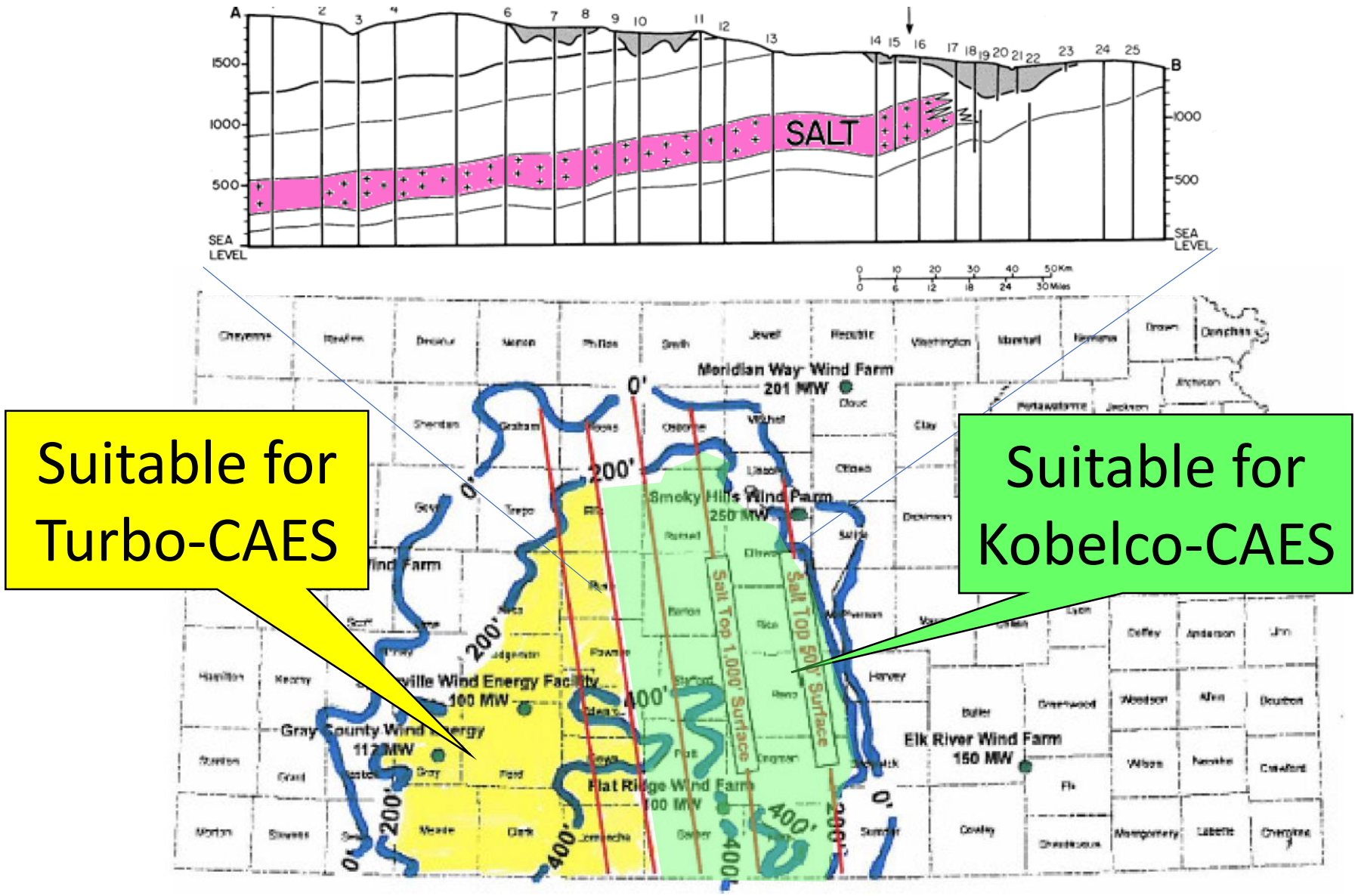
Hydrogen Economy Involves a Hydrogen Grid



Salt is also good for Compressed Air Storage

- Initial study suggested **Turbo-CAES** best location is where salt is…
- >200 ft thick
- >1800 ft under surface

- **Kobelco-CAES** is suitable for shallower salt



Federal Activity (Inflation Reduction Act)

Source of Carbon Oxides	Carbon Dioxide Storage Method	Current 45Q Credit Value (per metric ton)	Proposed 45Q Credit Value (per metric ton)
Industrial Facility (including electric generating units)	Enhanced Oil Recovery (EOR) with Geologic Storage or Utilization	$35/ton	$60/ton
Industrial Facility (including electric generating units)	Geologic Storage without EOR	$50/ton	$85/ton
Direct Air Capture Facility	Enhanced Oil Recovery (EOR) with Geologic Storage or Utilization	$35/ton	$120/ton
Direct Air Capture Facility	Geologic Storage without EOR	$50/ton	$180/ton