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Industrial Modeling for Demand Scenarios

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Acronyms and Initialisms

AAEE – Additional Achievable Energy Efficiency
ARCHES – Alliance for Renewable Clean Hydrogen Energy Systems
BAU – Business as Usual
BTM – Behind the Meter
CAISO – California Independent System Operator
CARB – California Air Resources Board
CC – Carbon Capture
CCUS – Carbon Capture, Utilization and Sequestration
CEC – California Energy Commission
CO2 – Carbon Dioxide
EV – Electric Vehicle
FS – Fuel Substitution
FSSAT – Fuel Substitution Scenario Analysis Tool
GHG – Greenhouse Gas (emissions)
H2 – Hydrogen
IEPR – CEC Integrated Energy Policy Report
IOU – Investor-Owned Utility
MKRP – Kern River and Mojave pipelines
PV – Photovoltaic
SMR – Steam Methane Reforming
SCE – Southern California Edison
TAC – Transmission Access Charge Area
USDoE – US Department of Energy
VMT – Vehicle Miles Traveled
ZEAS – Zero Emission Appliance Standard

Linkage of FSSAT Module to Base Forecasts (1)

- FSSAT Tool extends CEC's underlying Agriculture and Industrial demand forecasting models
- Basic features of the CEC industrial demand forecasting model
  - ➢ Covers only electricity and pipeline gas
  - ➢ Disaggregated into 46 industries based on NAICS codes
  - ➢ Seven end-uses for each of pipeline gas and electricity with shares that vary for each industry
  - ➢ Both electricity and pipeline gas forecasts are implemented for each of seven electric planning areas, and a special set of end-use customers in the oil extraction business in Kern County who are served directly from two interstate gas transmission pipelines – Kern River and Mojave pipelines
- Agriculture forecasting model uses econometric techniques

Linkage of FSSAT Module to Base Forecasts (2)

- Historic pipeline gas data provided by utilities to the CEC has been split into electric planning areas to enable all base forecasts and FS projections to be computed using electric planning area geography
  - Example: SoCalGas provides pipeline gas to LADWP, most of SCE, and Burbank-Glendale
  - Example: PGE provides pipeline gas to SMUD and other POUs in NCNC.
- Like other FSSAT modules, uses base 2023 IEPR pipeline gas forecasts to compute incremental impacts of additional fuel substitution scenarios
- Although pipeline gas is not the only fuel used in the industrial sector, it is the largest share of purchased energy. It is also the exclusive non-electric fuel used in many industries. Neither the CEC industrial demand forecast nor the FSSAT Industrial FS module address other fuels, so the EER Enhanced Pathways model is used to cover other fuels.
- Agriculture is considered as a single industry as a 47th industry in the tool

Ag and Industrial Fuel Substitution Module

- Substitutes electricity or hydrogen in lieu of pipeline gas
- For hydrogen, thermal end-use share of the base pipeline gas forecast separated into three categories
  - Process Heat-High
  - Process Heat-Low
  - Water Heat
- Fuel substitution is limited to a subset of pipeline gas end-uses based on the temperature range of the key processes in each NAICS industry
  - Pipeline gas to Electricity: Process Heat-Low and Water Heat
  - Pipeline gas to Hydrogen: Process Heat-High
- Each of Ag and 46 Industries defined by NAICS codes can have their own potential and adoption rate assumptions for each year
- Annual electric energy used to construct 8760 hourly electric load impacts using historic hourly load profiles.
  - Understanding annual energy and hourly load impacts at the granularity of the electric planning area is critical for generation system planning
- Each of three hydrogen production methods (SMR, electrolysis, or renewable pyrolysis) and three delivery modes (onsite, tanker truck, and H2 pipeline) can be selected for each industry with proportions changing through time.
- Given current data limitations, all scenarios are largely "what if" constructs using available technical literature and judgment.

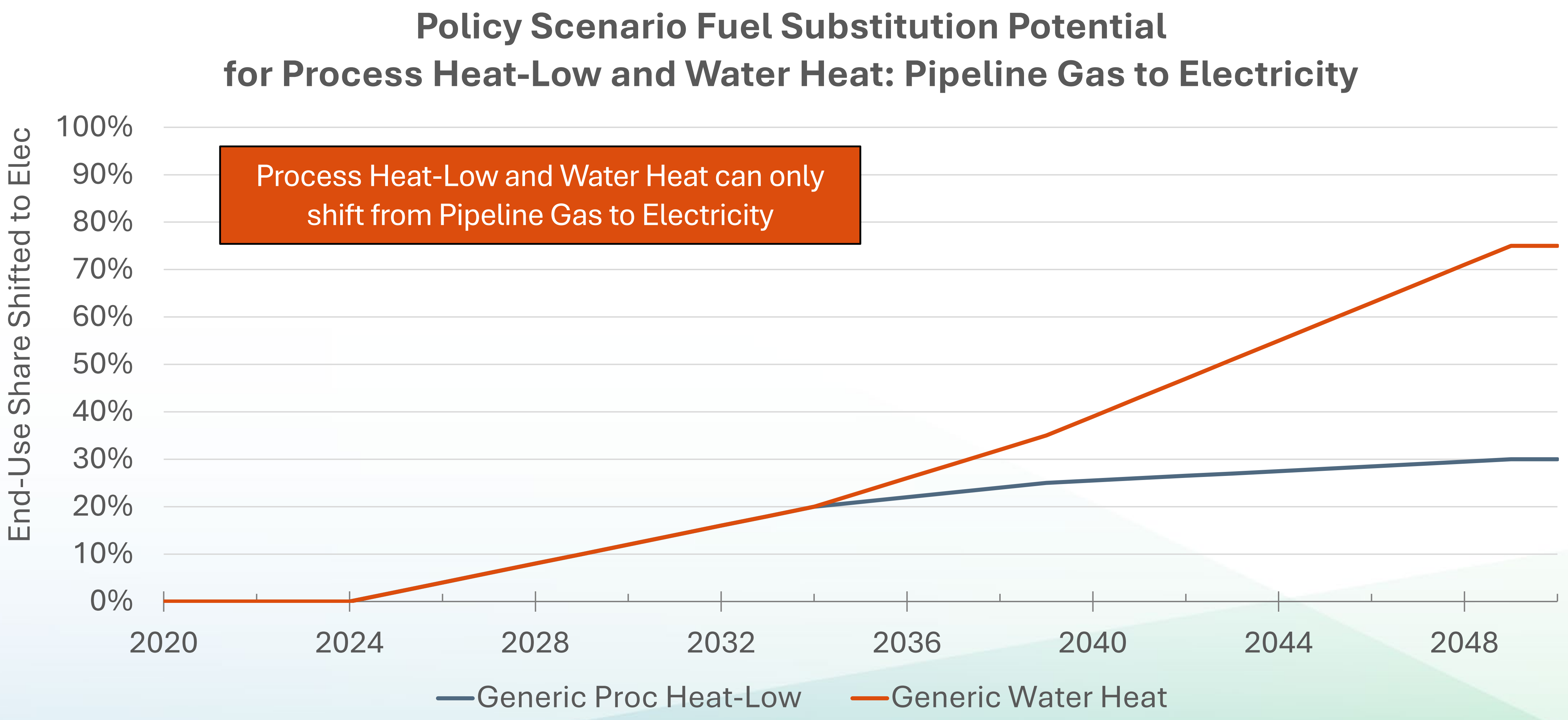
Federal Decarbonization Incentives

- Federal legislation creating tax incentives and grants are the principal rationale for adoption assumptions up to the early 2030s
- The Inflation Reduction Act includes two programs that provide funding for industrial decarbonization that are essentially fuel substitution programs
  - Section 13501 authorizes $10 billion for the 48C Manufacturing Tax Credit
  - Section 50161 authorizes $5.8 billion for the Advanced Industrial Facilities Deployment Program
- USDoE has implemented some demonstration programs with educational outreach efforts

Scenario Design Considerations

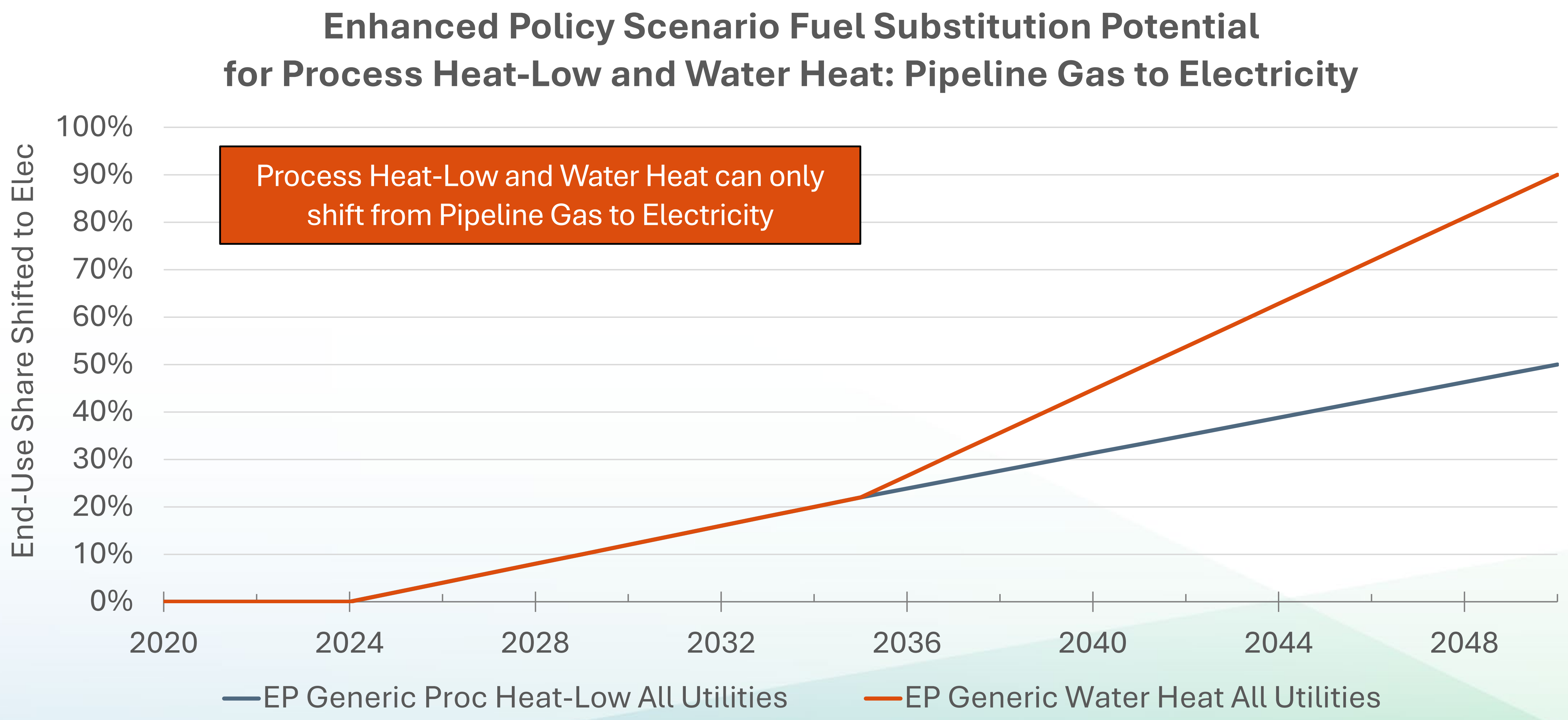
Scenario	Rationale for Scenario Design
Reference	No fuel substitution
Policy	▪ Moderate levels of Pipeline Gas to Electric fuel substitution for Water heat and Process Heat-Low using industrial-scale heat pumps ▪ More limited pipeline gas to Hydrogen for the Process Heat-High end-use where high temperatures cannot be achieved by heat pumps ▪ Potential expands through time as heat pumps and hydrogen combustion prove themselves through federal demonstration projects and the incentives adopted in the federal Inflation Reduction Act and other legislation ▪ Facilities that adopt hydrogen as a replacement for pipeline gas are assigned use of onsite electrolysis and storage
Enhanced Policy	▪ Adoption rates increase after early 2030s as decarbonization technologies become more common and they become part of the conventional set of choices for industrial facilities ▪ Potential grows after early 2030s as manufacturing capacity for these products expands, but at a slower pace than when stimulated by federal incentives

FS Potential for Pipeline Gas Shift to Electricity (1)



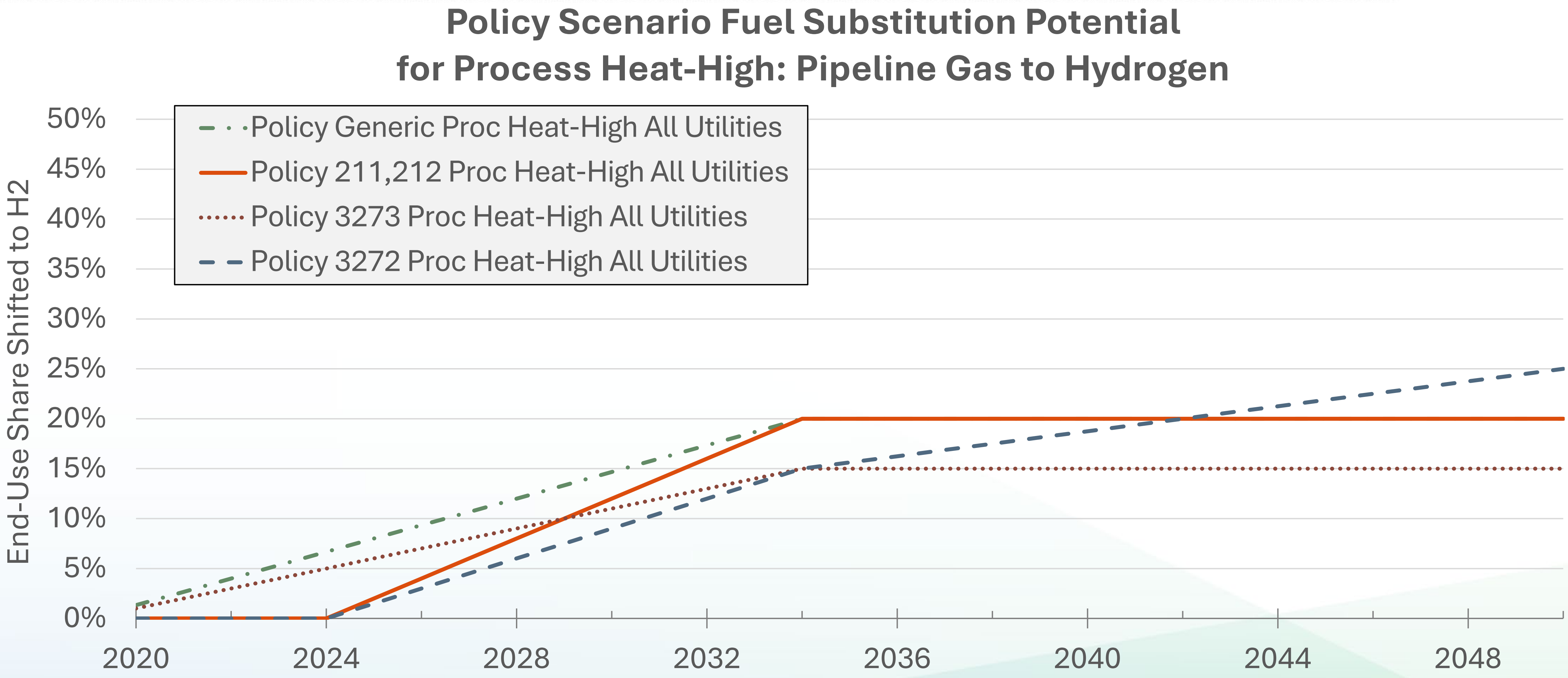
Source: CEC

FS Potential for Pipeline Gas Shift to Electricity (2)



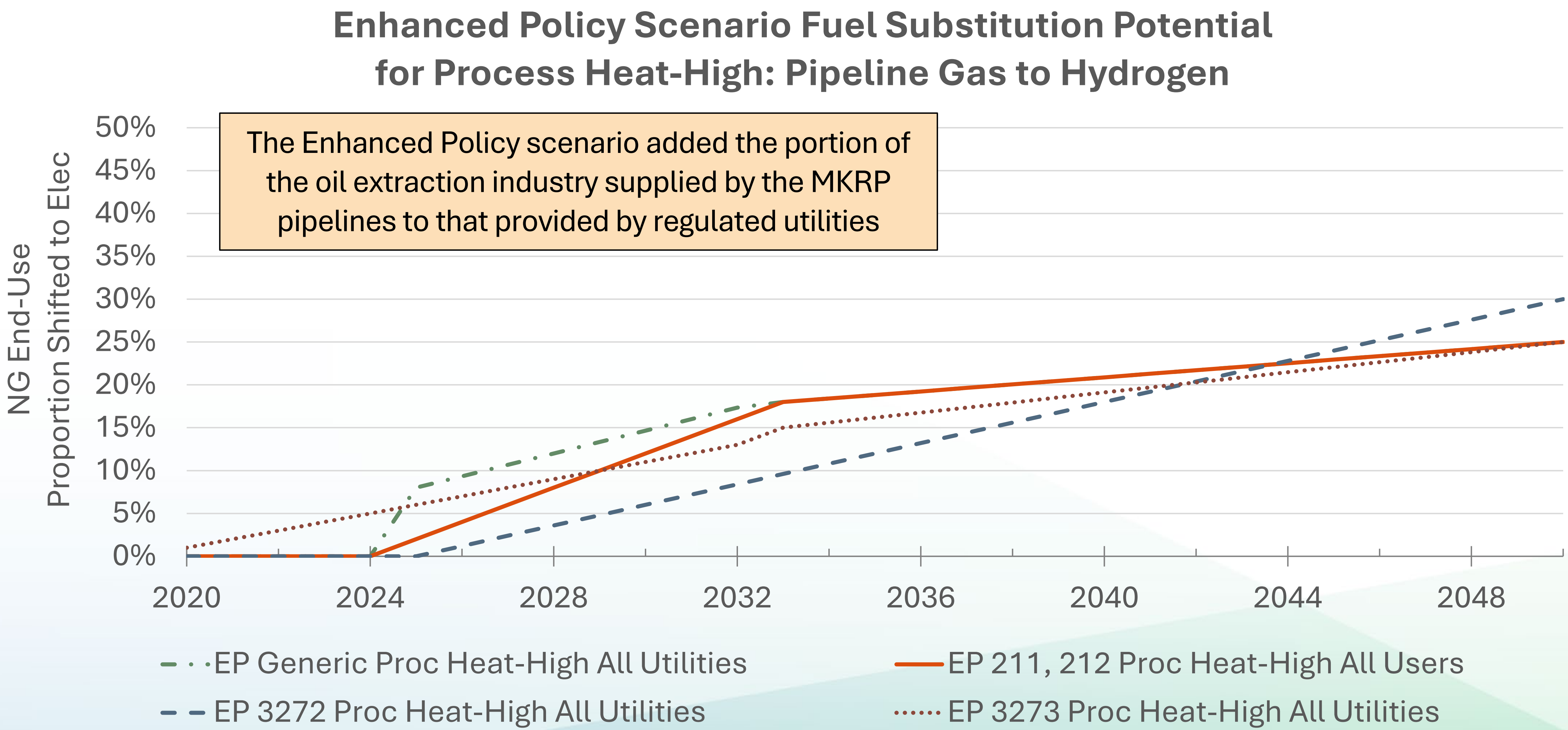
Source: CEC

FS Potential for Pipeline Gas Shift to Hydrogen (1)



Source: CEC

FS Potential for Pipeline Gas Shift to Hydrogen (2)



Source: CEC

Summary of Potential FS Shares in 2050

Industry Applicability (NAICS)	End-Uses for Fuel Substitution	Type of Fuel Substitution	Policy	Enhanced Policy	Special Notes
Generic	Process Heat-Low	NG>>E	0.3	0.5	
Generic	Water Heat	NG>>E	0.75	0.9	
Generic	Process Heat-High	NG>>H2	0.2	0.25	
211, 212	Oil & Gas Extraction	NG>>H2	0.2	0.25	supplied by utilities
211, 212	Oil & Gas Extraction	NG>>H2	0	0.25	supplied by MKRP pipelines
3272	Glass (revised)	NG>>H2	0.25 *	0.25	PC penetration rate revised downward
3273	Cement	NG>>H2	0.25	0.25	

*Glass industry potential revised downward from the value used in the Policy Scenario provided to the SB 100 process

Hydrogen Pipeline Sensitivity

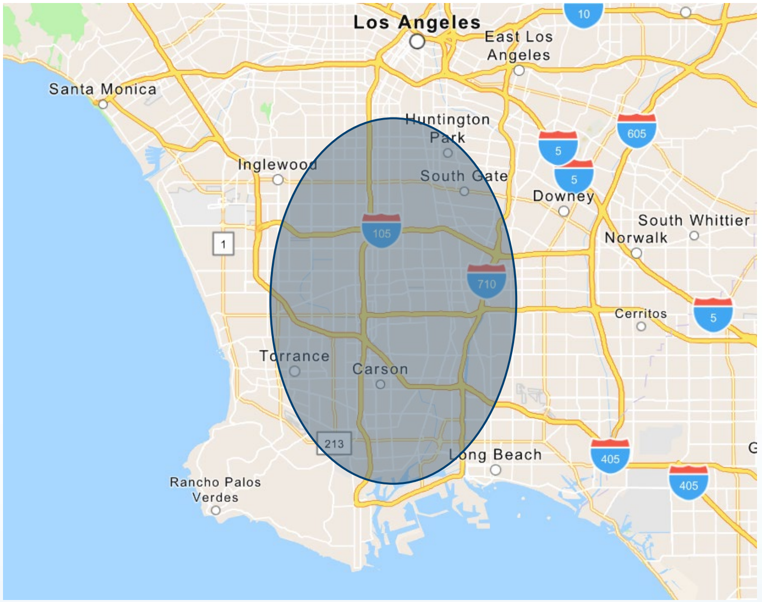
- There are at least two well known hydrogen pipeline development efforts
  - The ARCHES public-private partnership, awarded $1.2 billion from the federal government as one of the hydrogen hubs to be created in multiple regions of the country
  - The Angeles Link, a smaller effort to create a hydrogen pipeline from Utah oil fields to support conversion to hydrogen fuel for LADWP powerplants
- SB 1075
  - Pursuant to the direction of SB1075, electric generation and transportation usage were addressed in Chapter 2 of the 2023 IEPR
  - The 2023 IEPR identifies a series of issues for industrial application of hydrogen.
    - Assessing industrial usage is important since large portions of natural gas consumption in industry cannot be electrified
  - The DS project team created a basic “what if” scenario to initiate follow-up to some of the industrial assessment issues discussed in the 2023 IEPR
- This sensitivity used all the assumptions of Enhanced Policy scenario **<u>except</u>** industrial hydrogen FS potential and adoption rates, production methods, and transportation options.

Enhanced Policy Sensitivity - Hydrogen Pipeline

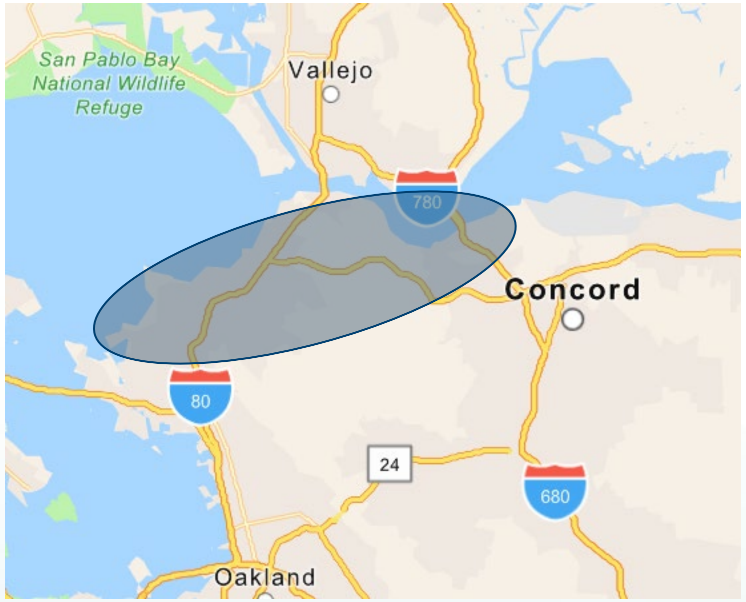
- Multiple ways to produce and transport hydrogen
- Prominent combinations
  - Steam methane reforming onsite
  - Steam methane reforming using existing/augmented H2 pipelines
  - Electrolysis onsite using grid supplied electricity
  - Electrolysis offsite using renewable generation delivered by H2 pipeline network
  - Combinations of these
- The Policy Scenario and Enhanced Policy Scenario assume 100% onsite electrolysis for all hydrogen consumption
- The Enhanced Policy sensitivity - H2 pipeline examines a “what if” scenario that uses a hypothetical H2 pipeline delivery mechanism supplying a limited subset of major industrial customers in three areas of the state
  - Wilmington/Carson industrial area of the LA Basin
  - Refinery/chemical complex along San Pablo and Suisun bays in Northern California
  - Oil extraction facilities in and around Bakersfield.
- Impacts occur only in the SCE, PGE, and LADWP planning areas

Regional H2 Pipeline Locations

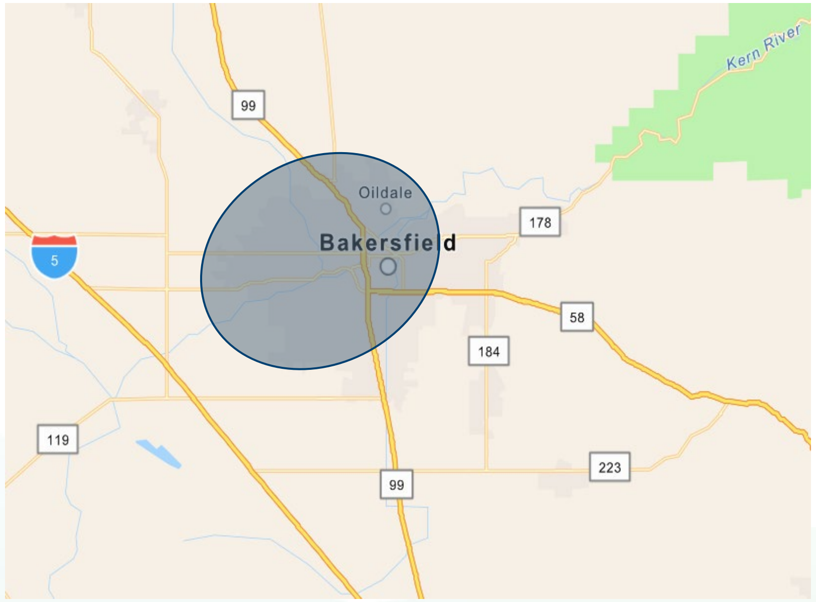
Metro LA



Bay Area



Bakersfield Oil fields



Hydrogen Pipeline Sensitivity - Approach

- Goal – Assess the differences in hydrogen consumption if hydrogen pipelines were available as an alternative/supplement to onsite production
- Approach – hypothesize development of hydrogen pipelines from existing production facilities tying into renewable production through time
- Pipeline delivery capability assumed to occur in three stages – 2030, 2040, and 2050
- Since hydrogen pipelines were assumed to be privately developed, the route and capacity must be directly linked to specific customers willing to pay for pipeline development and to consume hydrogen once the pipeline reaches that facility
- Each of three pipeline routes were chosen to facilitate connection to largest pipeline gas customers along with some smaller facilities adjacent to the route
- Some onsite hydrogen production/consumption in the base EPS scenario was shifted to pipeline-sourced hydrogen, but some net increase in onsite production also occurred

Hydrogen Pipeline Sensitivity - Methodology

- Two databases with detailed locational data were used to identify the possible linkage between a pipeline route and major industrial facility usage of pipeline gas
  - CARB Major Industrial Facilities data base
  - Federal pipeline database identifying pipeline routes, commodity delivered (natural gas, crude oil, refined oil products, hydrogen, etc.) and the status of each segment.
- GIS software used identify the proximity of any large industrial facility to an existing or hypothesized pipeline route
- Since hydrogen is assumed to only displace Process Heat-High the potential for hydrogen consumption was limited to this share of total industrial natural gas consumption
- Annual hydrogen consumption in each year was the minimum of projected volumes of Process Heat-High and the pipeline delivery capability in each year
- Four metrics can describe the results of this sensitivity
  - Hydrogen consumption
  - Pipeline gas displaced
  - Electricity required for onsite grid-supplied electrolysis
  - Electricity required for remote hydrogen production by renewable supported electrolysis

2050 Results for Demand Scenarios/Sensitivities

Variable	Units	2023 IEPR Forecast	Policy	Enhanced Policy	EP-H2 Pipeline Sensitivity
Pipeline Gas Displaced	MM Therms	0.0	109	371	1,830
Remaining Ind NG	MM Therms	6,283	5,840	5,537	4,097
Direct FS Elec Added	GWh	0.0	442	1,223	1,223
Hydrogen Added	MM Kg	0.0	44	165	1,250
Elec from Onsite Electrolysis	GWh	0.0	2,313	8,650	11,772
Elec for Renewable Hydrogen via Pipeline	GWh	0	0	0	52,600
Direct Elec GHG Emission Reduction	MM Tonnes CO2e	NA	0.27	0.8	0.8
Direct H2 GHG Emission Reduction	MM Tonnes CO2e	NA	0.31	1.2	8.9

Conclusions

- The FSSAT Ag and Industrial tool has been designed to facilitate a wide range of alternative input assumptions
- The Enhanced Policy scenario and the EPS H2 pipeline sensitivity specifications are largely based on judgment, and many alternative specifications are equally plausible
- The projections should not be considered certain enough to be included in forecasts used for actual resource planning or project commitments
- Much more extensive data about industrial sector processes is needed to reduce the uncertainty of these projections
- An interagency effort to acquire and share improved data is necessary to thoroughly understand the real issues confronting decarbonization of the industrial sector

Thank You!

Questions?

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