NW Natural®

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September 24, 2021

VIA ELECTRONIC FILING

Public Utility Commission of Oregon
Attention: Filing Center
201 High Street SE, Suite 100
Salem, Oregon 97301-3398

RE: UM 2178, Natural Gas Fact-Finding Per Executive Order 20-04
NW Natural's Compliance Modeling Presentation – Second Update

Northwest Natural Gas Company, dba NW Natural (NW Natural or Company), hereby submits a second updated presentation and accompanying workbook in docket UM 2178.

NW Natural identified an error in its calculation of the costs associated with energy efficiency in the workbooks it filed in this process on September 8, 2021 and the presentation presented on September 14th based upon that work, subsequently filed on September 15, 2021. The per unit cost of energy efficiency savings in a given year for some energy efficiency measures (energy efficiency from transportation schedule customers and incremental savings from existing programs) was incorrectly applied to the cumulative energy efficiency savings of these measures over the entire planning horizon, rather than the incremental savings in that year. This correction reduces the expected cost of energy efficiency in most years of the base case and the sensitivities/scenarios. The workbook has been updated with the appropriate calculation and the slides in the presentation that rely upon energy efficiency costs have also been updated.

If you have any questions about this filing, please do not hesitate to contact me at zachary.kravitz@nwnatural.com or 503-610-7617.

Sincerely,

/s/ Zachary Kravitz

Zachary Kravitz
NW Natural
Director, Rates and Regulatory Affairs

OPUC Natural Gas Fact-Finding Workshop #3- Modeling

UM 2178, September 14, 2021

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Agenda

Introduction

Existing Processes and Forecasts

Climate Protection Program Rules

Options for Emissions Reduction

- Demand-side Options
- Supply-side Options

Base Case Compliance

Scenario Compliance

Introduction to CPP Modeling

- This modeling represents a base-case of 30-years of compliance with the Climate Protection Plan and requested scenarios from Staff of the OPUC.
  - We are still waiting on final rules to be issued by the ODEQ, so it is very possible that this modeling will change after the CPP is finalized.
  - As we move forward with decarbonizing the natural gas system, our modeling will continue to evolve and change as we learn more and pursue new technologies.
  - Given compressed timeframe for the fact-finding, we could not model in the same level of detail as an IRP.

- Our next IRP will utilize final CPP rules in our long-term planning.
  - In our IRP process, we have more time to analyze, plan, and include our full risk-modeling software.
  - Our stakeholders will also have far more time to analyze and review our modeling in the IRP process.

- When we look at financial impacts to customers, we focus on customer bill impacts - the actual dollars spent by customers.
  - Changes to rates do not necessarily equate to equivalent customer bill impacts.

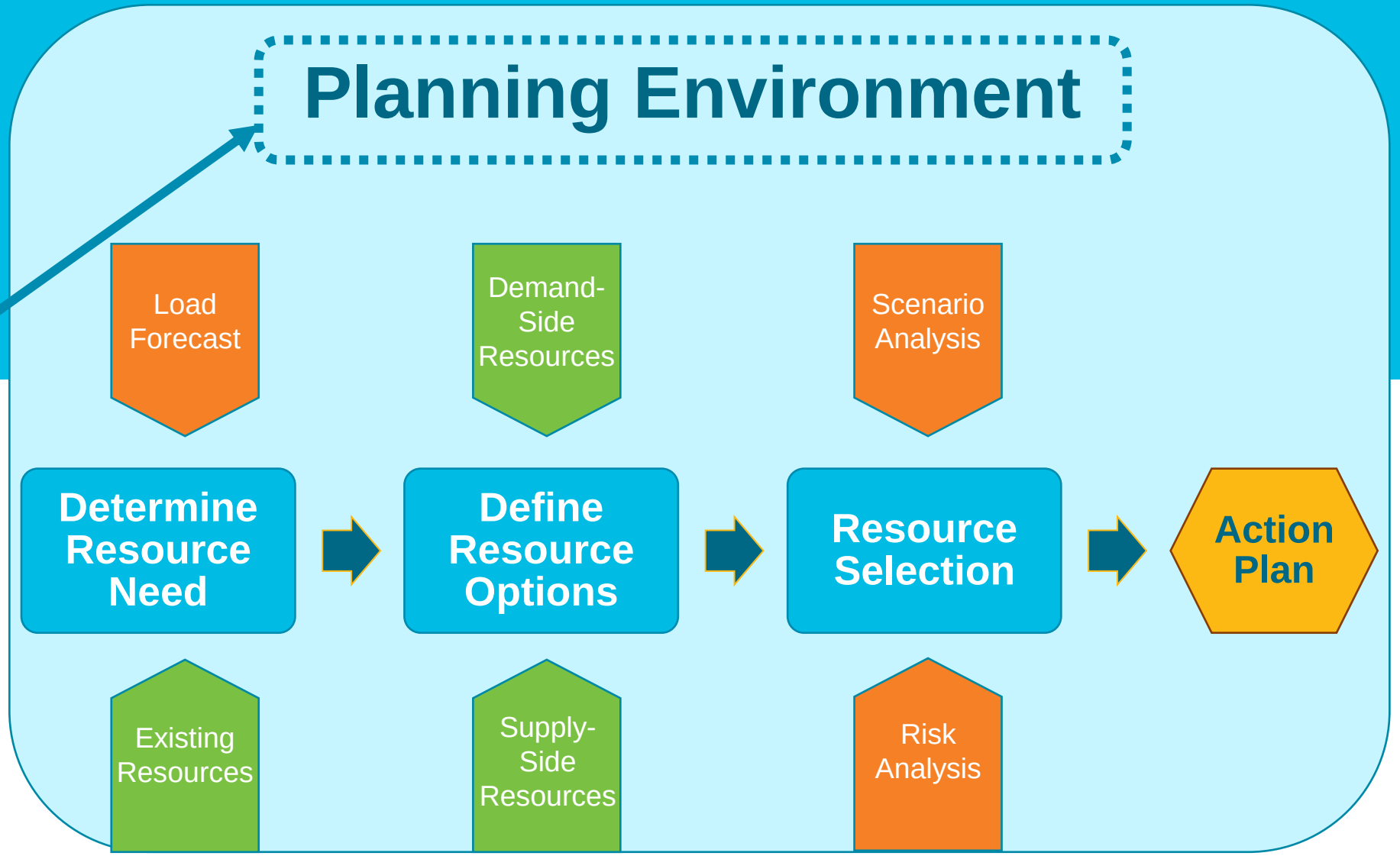
- The modeling does not incorporate CPP assistance programs to energy burdened customers – but our regulatory tools should.

- NW Natural also continues to support a comprehensive analysis of decarbonization pathways for the electric and gas systems, including considerations of costs for all Oregonians, resource adequacy, resiliency, among other factors.
  - Exploring ways to jointly plan between electric and gas utilities should also be considered a regulatory tool we can use.

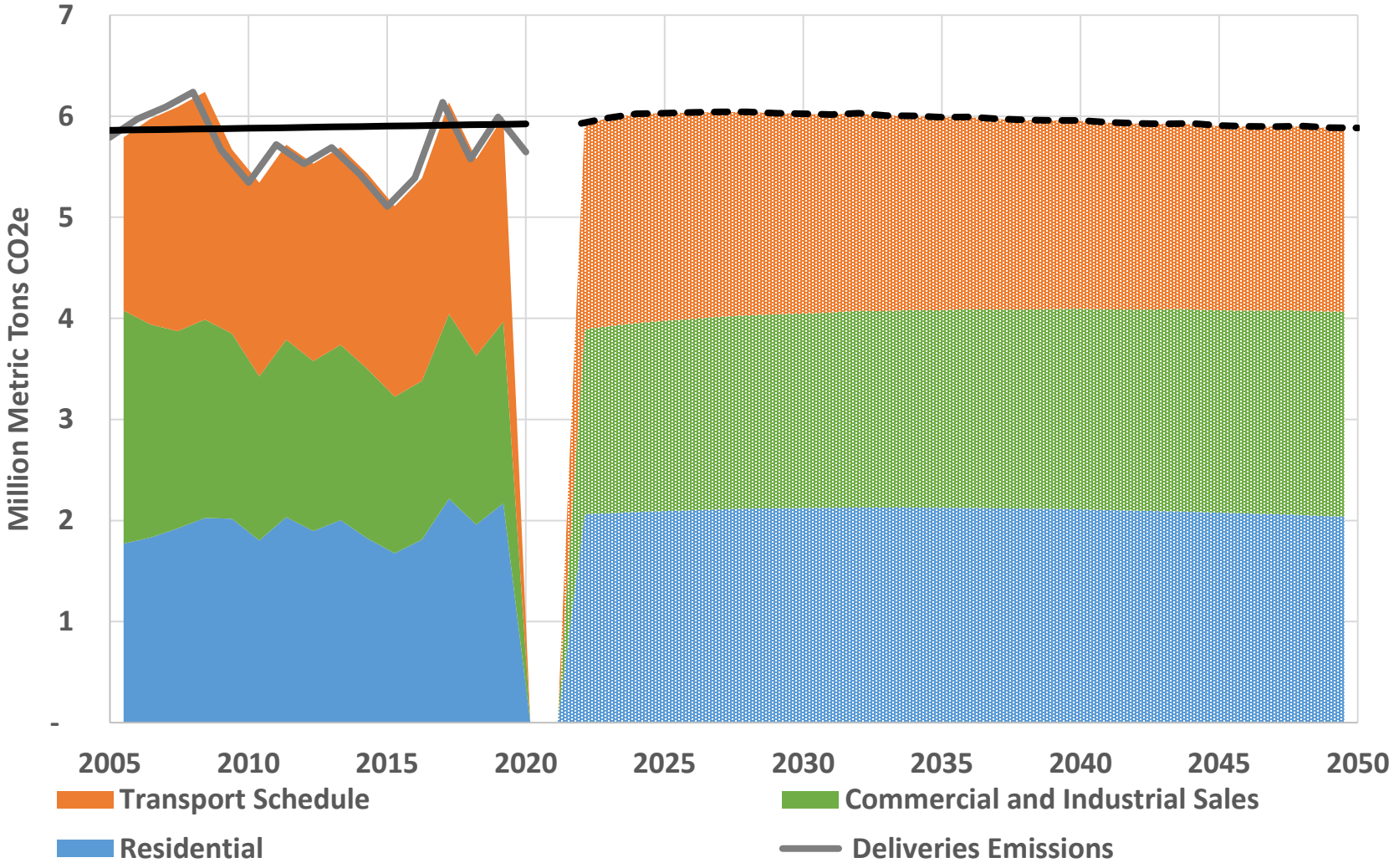
- We are happy to take questions on our presentation today, but we have limited time. Please reach out to us if you'd like more time to discuss the presentation.

Resource Planning Process and Current Forecasts

The Climate Protection Program (CPP) is a potentially transformational change in the planning environment that impacts the resource needs, the options to meet those needs, and the actions for compliance for NW Natural's customers



NW Natural Load History and Forecast in terms of CPP Compliance



- Includes gas delivered – but not sold – by NW Natural (i.e gas delivered on Transportation Service Schedules)
- Shows emissions as if all load was served by conventional natural gas (i.e. does not show expected decrease in emissions due to RNG and other supply-side actions)

Seasonal Load Breakdown by End Use- 2018 IRP

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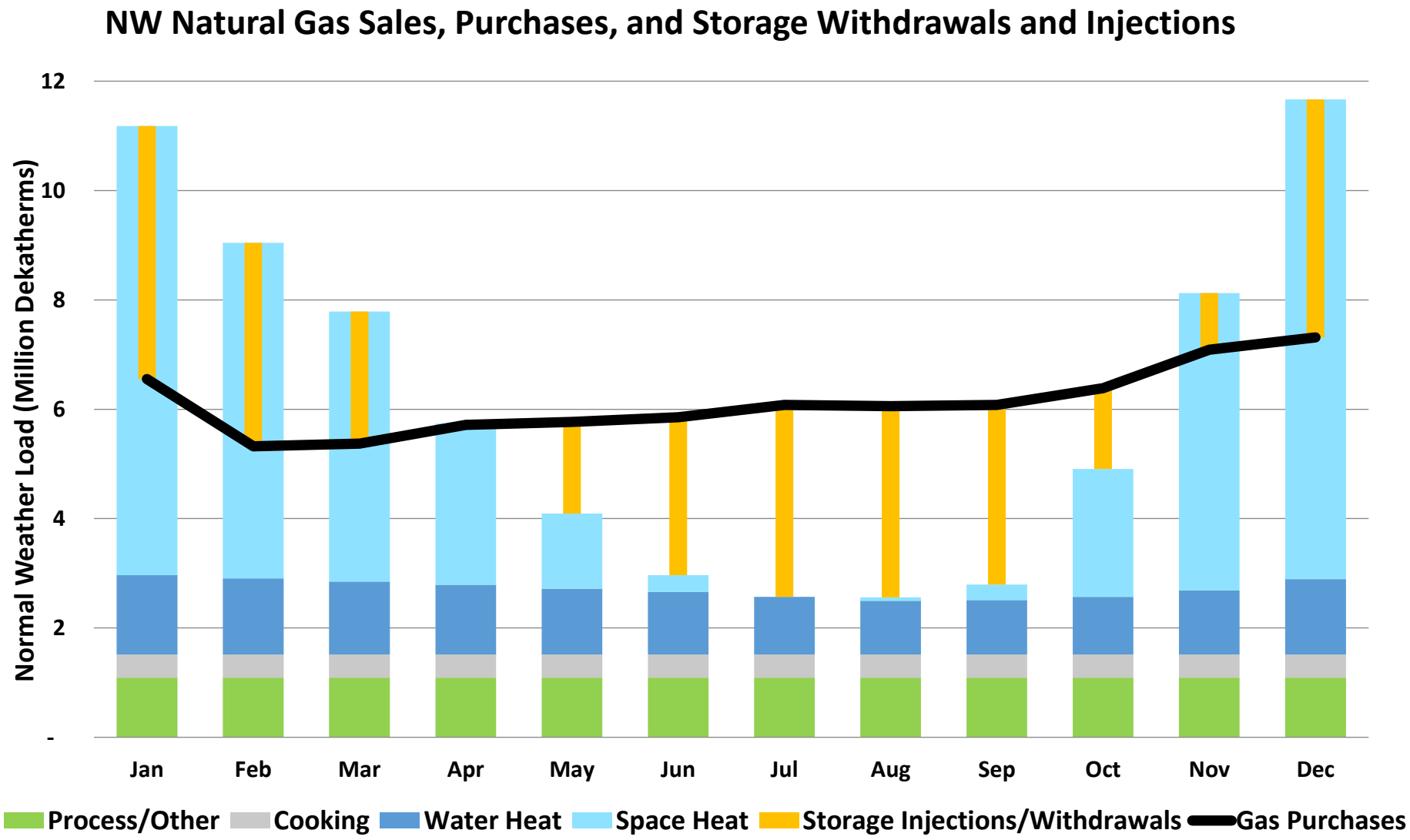
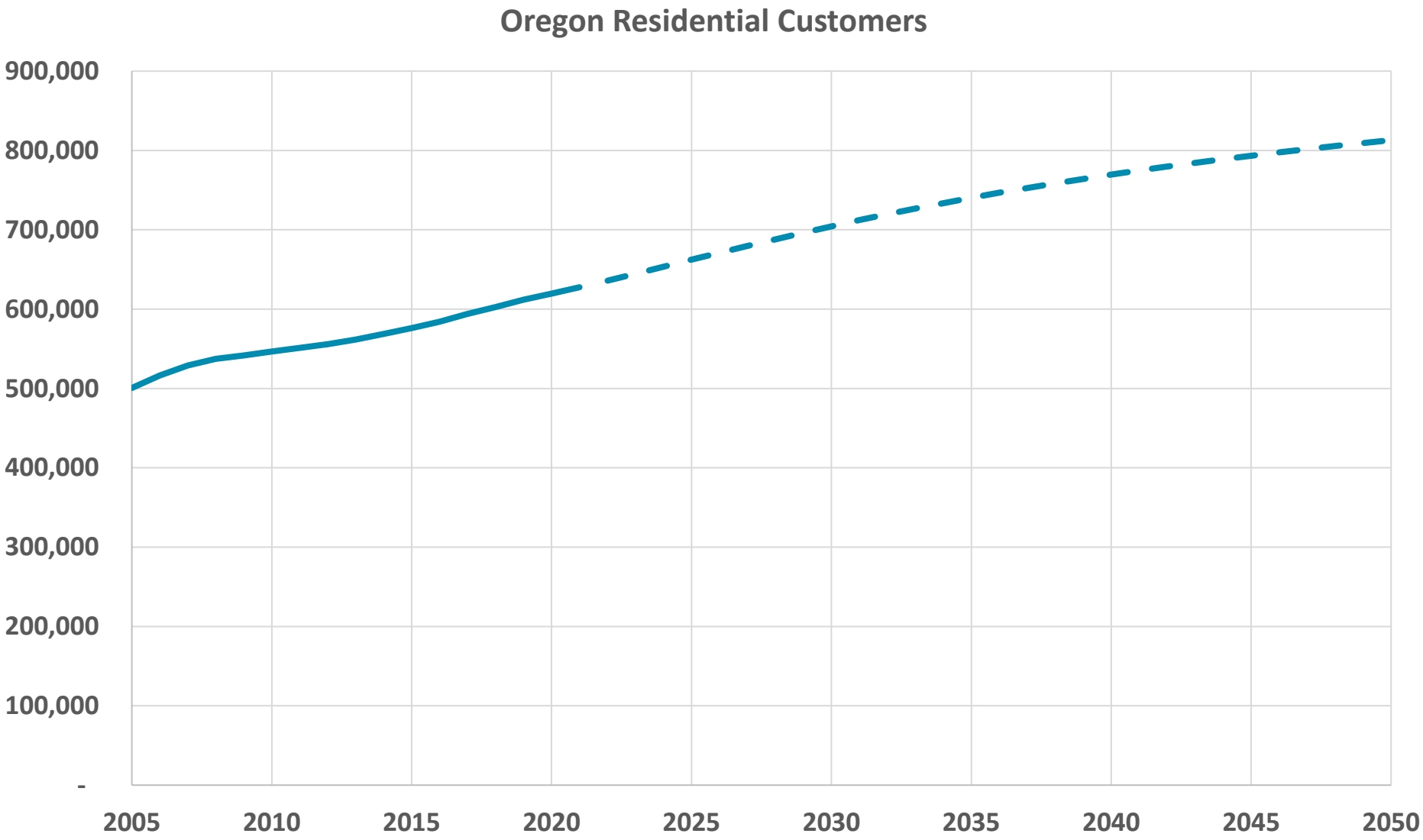


- Load is highly seasonal
- Seasonality needs are cost-effectively met with existing energy storage
- Peak load is roughly 3 times the average load throughout the year
- Does not include transportation schedule load

Customer Growth Expectations- IRP Update #3



- Expected Oregon Residential Customer Growth (CAGR) is 0.9% per year

Per Customer Emissions Forecast- IRP Update #3

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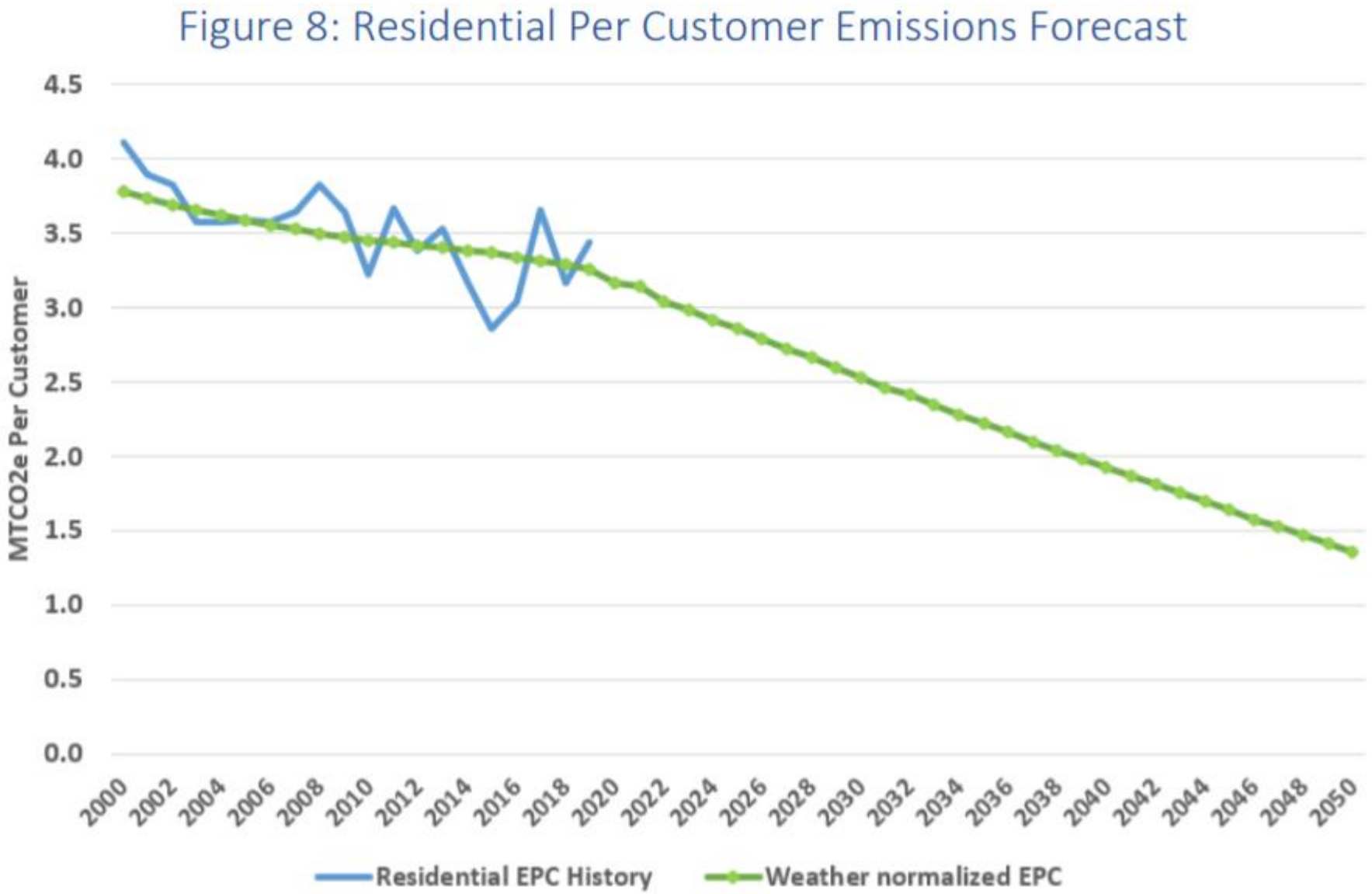
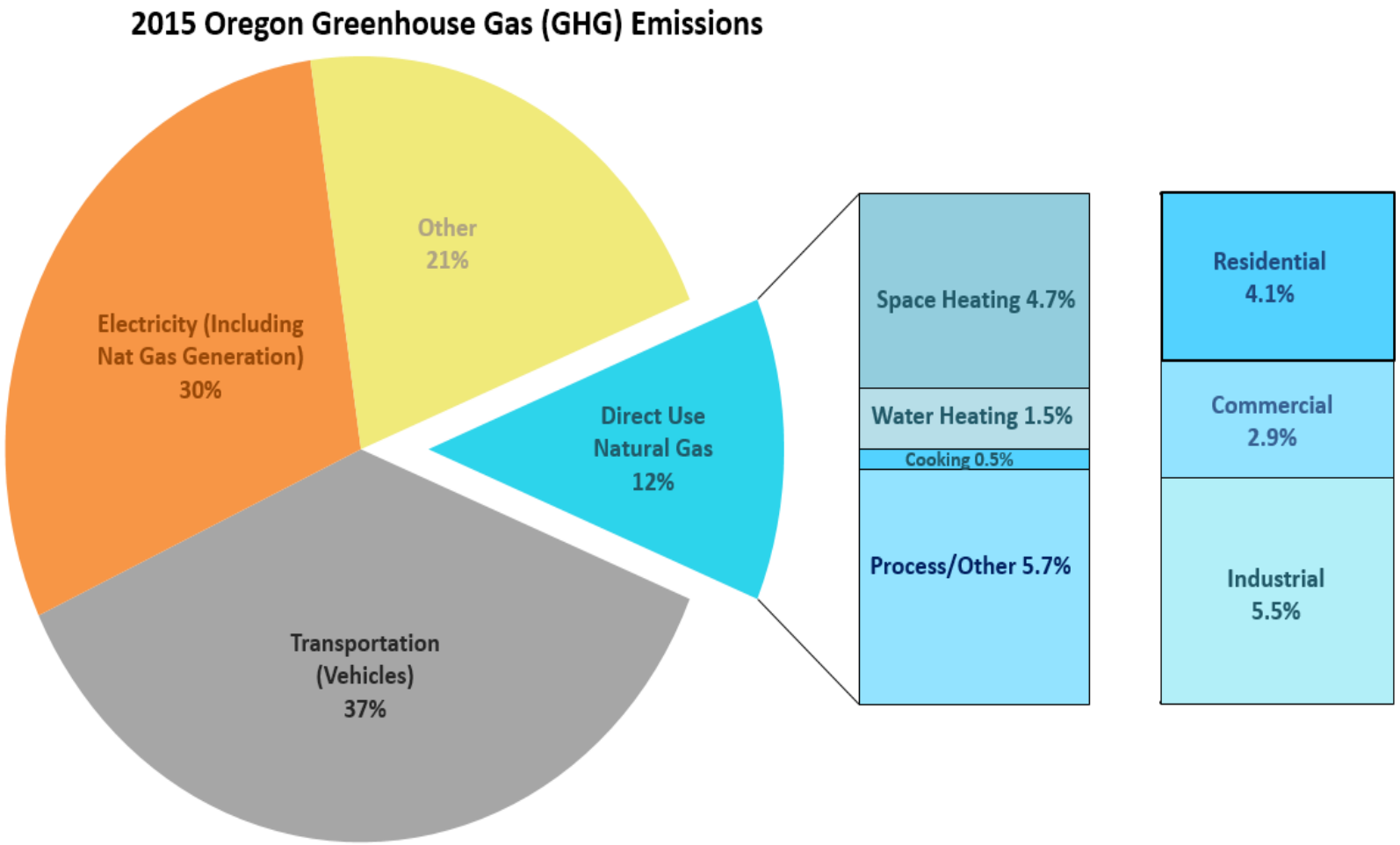


- Pre-CPP expectations
- Includes Washington Customer and Smart Energy
- Combined Impact of Renewable Supply Penetration and Usage Decline Expectations

Putting Emissions in Context – 2018 IRP



Sources: (1) State of Oregon DEQ In-Boundary GHG Inventory Preliminary 2015 Figures- Residential, Commercial, and Industrial sector emissions are those that are not from electricity or natural gas use (2) Natural gas breakout: NW Natural analysis

- Roughly 70% of Oregon's space heating needs are served by direct-use natural gas
- Roughly 1/3 of direct use natural gas used in Oregon is on transportation schedules (this does not mean cars and trucks in this context)
- Roughly ½ of the natural gas associated with Oregon's energy use is used in electric generation
- Direct use gas' share of emissions have remained relatively constant over the last decade
- NW Natural represents roughly 80% of gas utility emissions covered by the CPP

Pre-CPP Emissions Forecast- IRP Update #3

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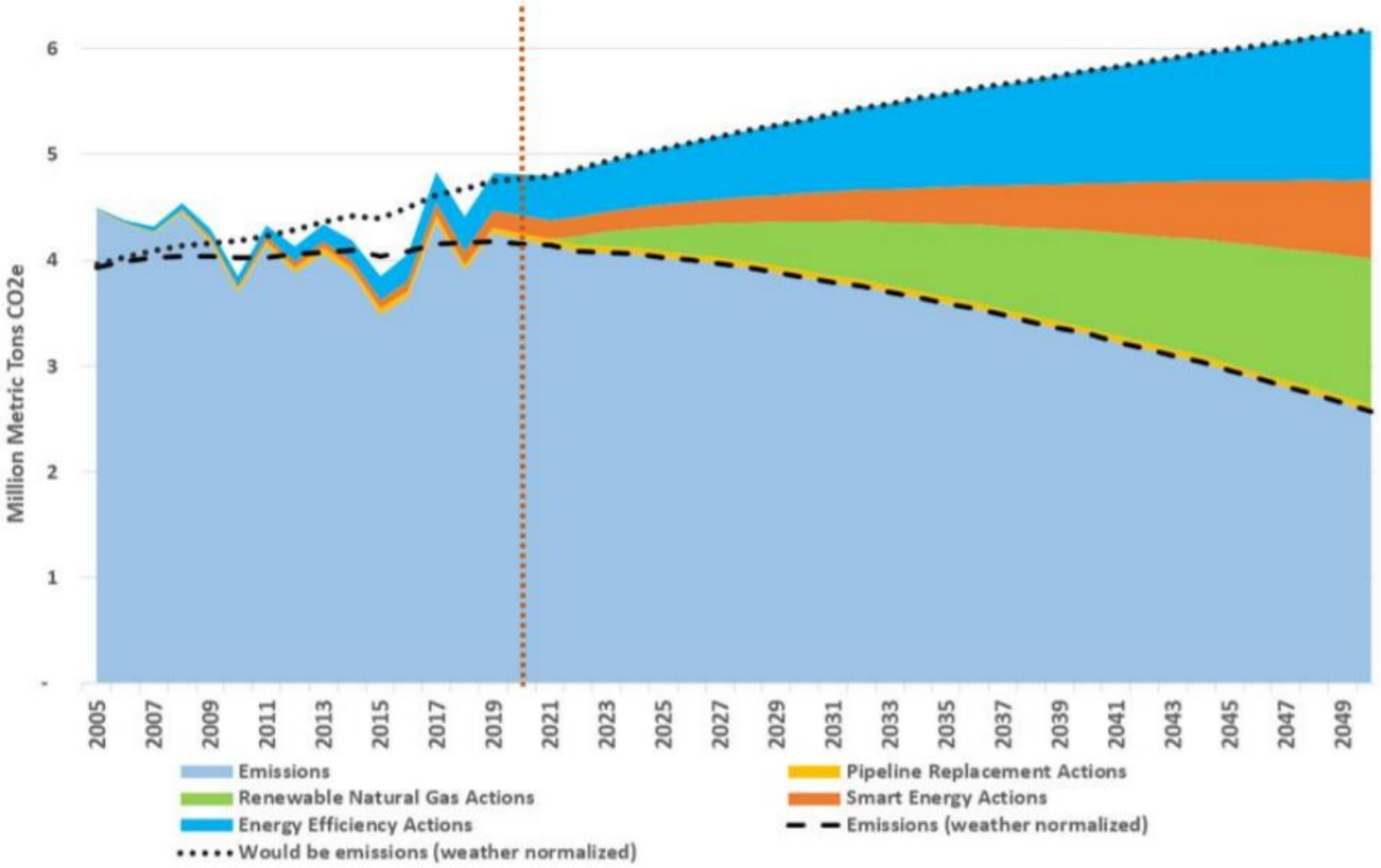
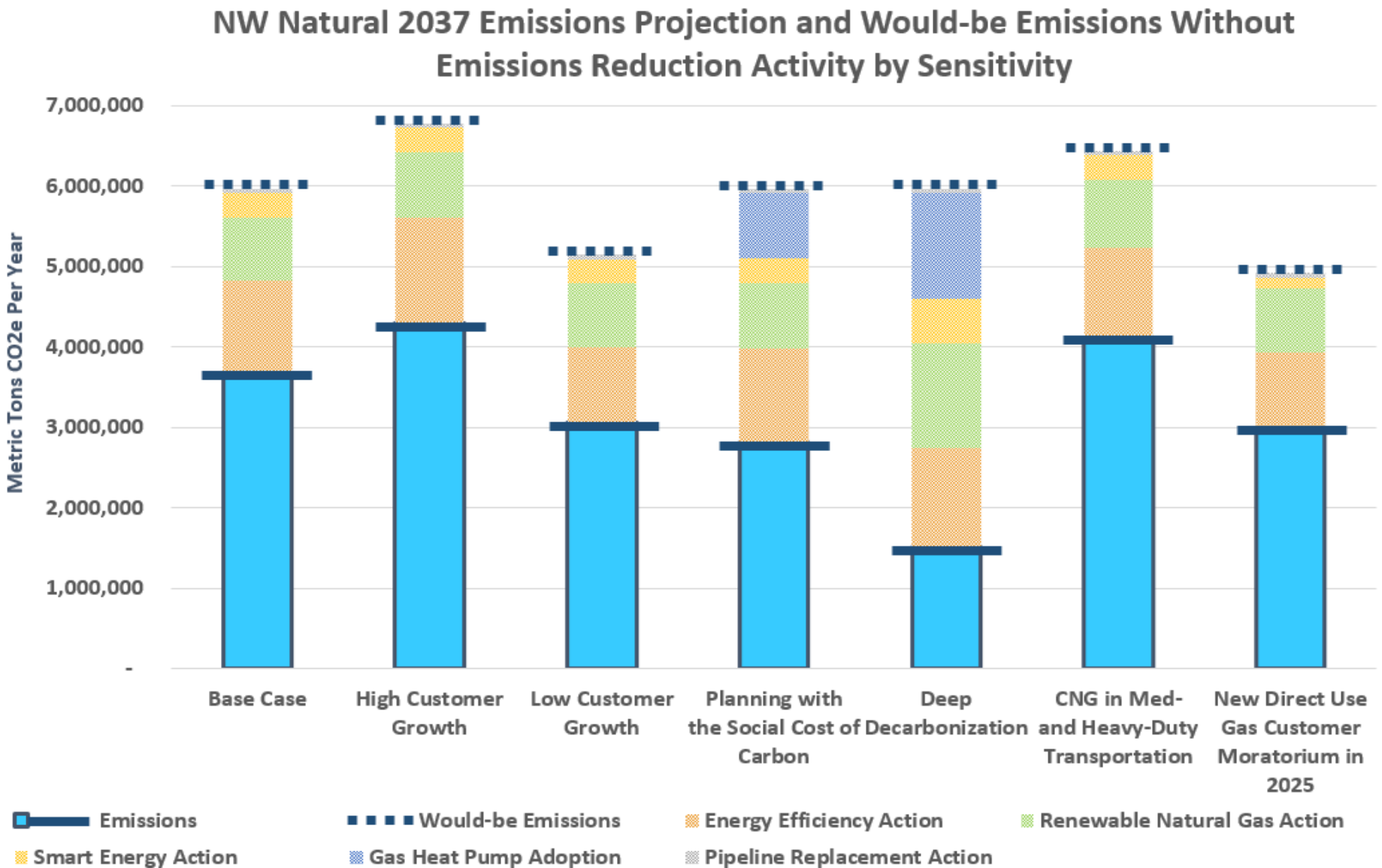
Figure 7: NW Natural Emissions Forecast Update



- Shows Emissions from Sales Customers Only
- Includes NW Natural's Washington Service Territory
- Includes Smart Energy Program
- Overall Emissions Trajectory has been flat since 2005 and is expected to fall even with the CPP Program

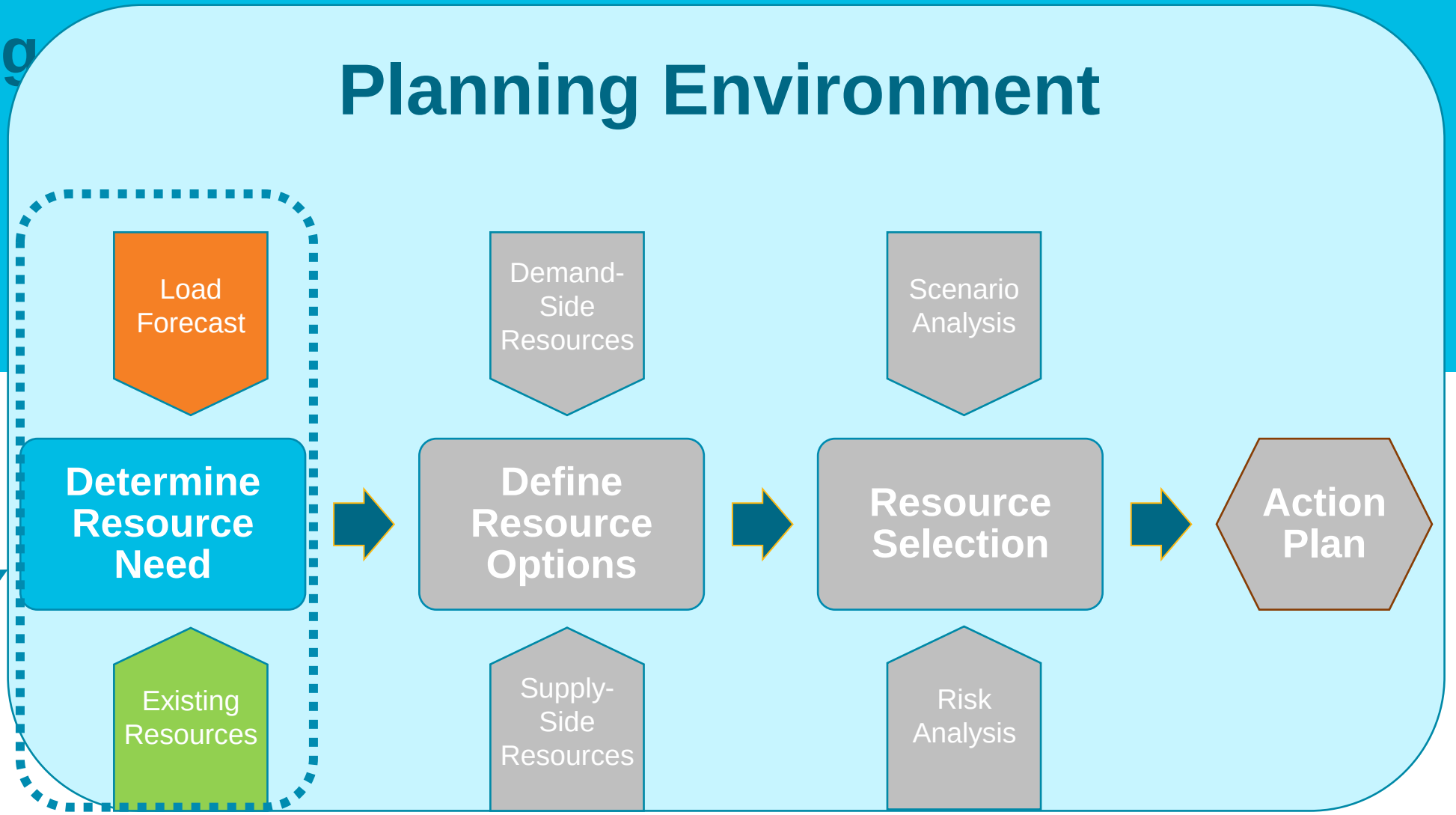
Scenarios Completed in 2018 IRP



- Environmental policy uncertainty was a key driver of analysis in the last IRP
- Implementing the CPP is likely to be the primary driver of resource decisions in the upcoming IRP

Understanding NW Natural's CPP Obligations

Given the draft CPP rules, the first step is determining what would be required to comply with the program



Climate Protection Program Overview

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Cap and reduce program

Covered entities include: fuels for transportation (e.g. cars and trucks), natural gas utilities, and large industrial emissions

LDCs are responsible for emissions from all customers, excluding a few large stationary sources, but including transport customers

Cap trajectory and emission reduction limits. LDC annual compliance instrument distribution is written into the rules:

- 2022: 5,931,657 compliance instruments
- 2035: 3,262,412 compliance instruments (55% reduction)
- 2050: 1,186,331 compliance instruments (80% reduction)

Banking and trading of compliance instruments is allowed

CPP Status and Timeline

August 5: Complete draft rule language published

October 4: Public comment deadline

December 2021: EQC meeting to consider proposed rules

January 2022-December 2024: First compliance period

November 15, 2025: First compliance demonstration

Compliance Mechanisms

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Included in the draft rule language:

- Reduced consumption/ energy efficiency
- RNG
- Community Climate Investments (CCI)

More clarity needed in rules:

- Smart Energy program
- Hydrogen
- Carbon capture sequestration

Community Climate Investment (CCI) Provisions

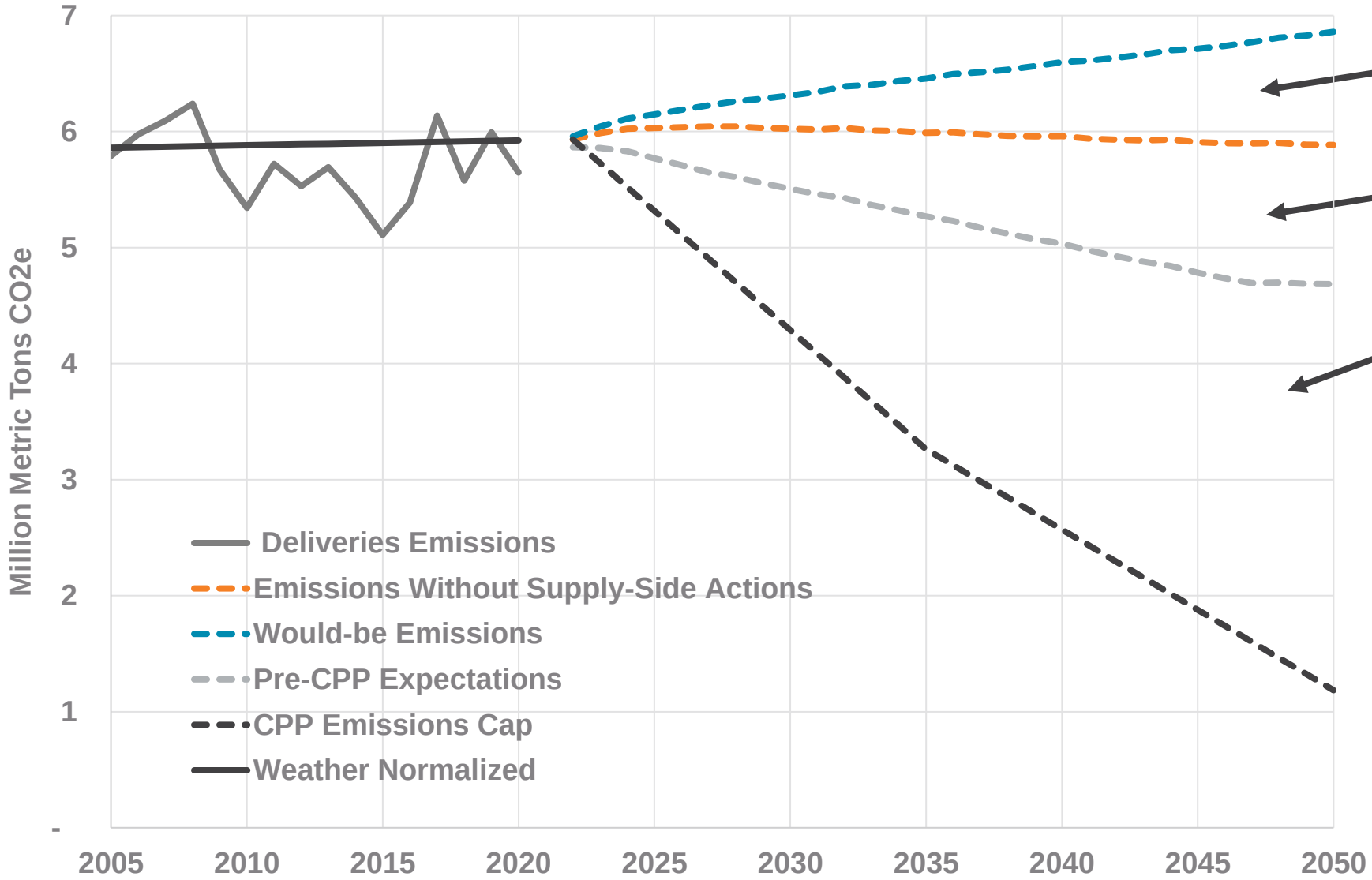
Price is fixed in the rule with a starting price of $81 per ton of CO2e

Paying this price provides covered party with a credit for one metric ton of emissions to deduct from their emissions report

Allowable usage of CCI Credits to demonstrate compliance is limited in the rule language:

- Compliance period 1 (2022-2024): 10% of Emissions
- Compliance period 2 (2025-2027): 15% of Emissions
- All subsequent compliance periods(2028-2050): 20% of Emissions

NW Natural's CPP Compliance Needs



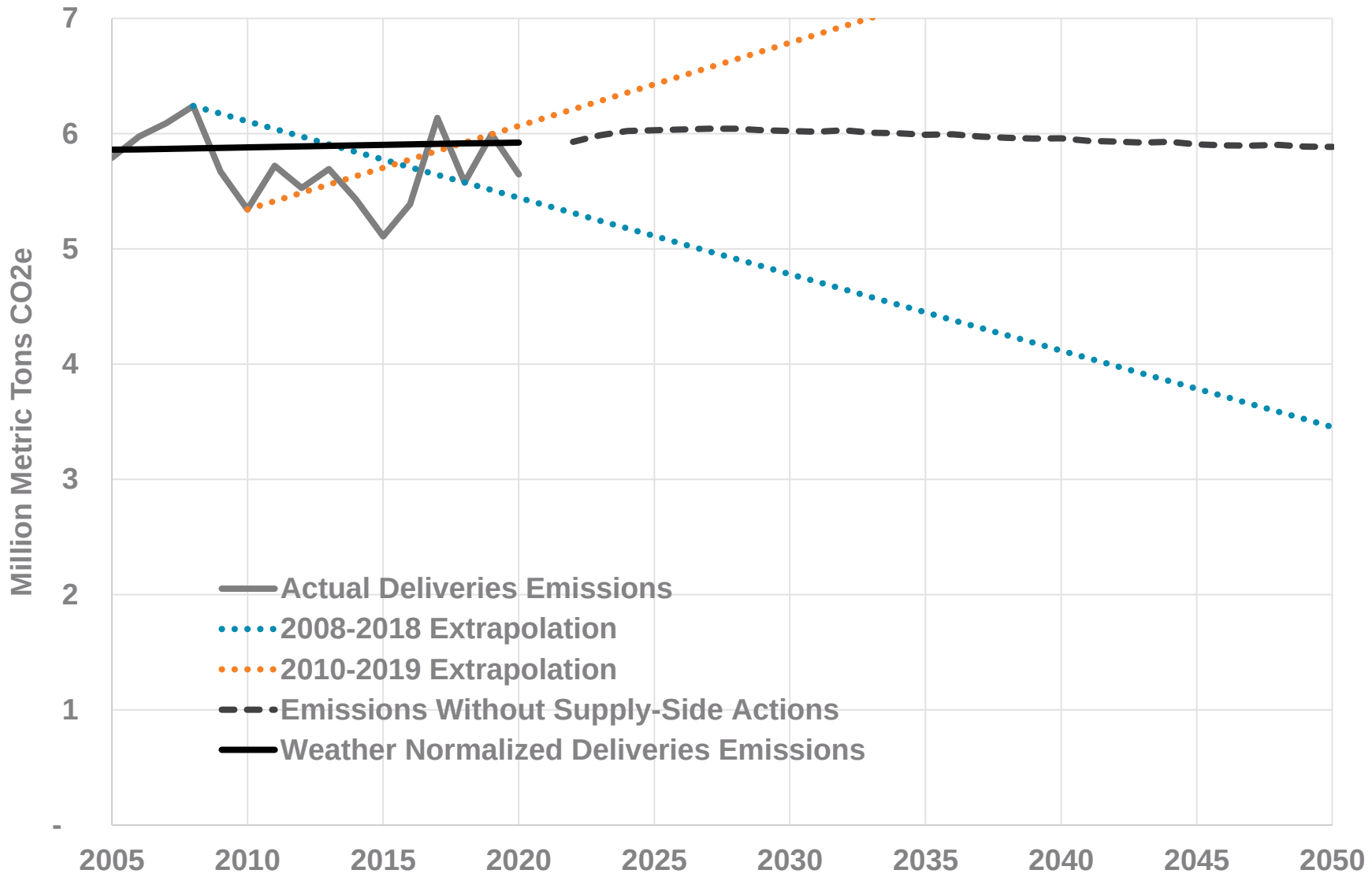
Impact of Expected Energy Efficiency

Impact of Expected SB 98 Actions

Incremental Action Required to Comply with CPP

- Inclusive of Transportation Schedule loads and excluding Washington, NW Natural's weather normalized emissions are declining
- Does not include Smart Energy
- Normal Weather emissions have remained constant for the last 15 years
- Weather Normalization is an important consideration in understanding emissions
- Forecast is of normal weather, which includes a trend accounting for our warming climate

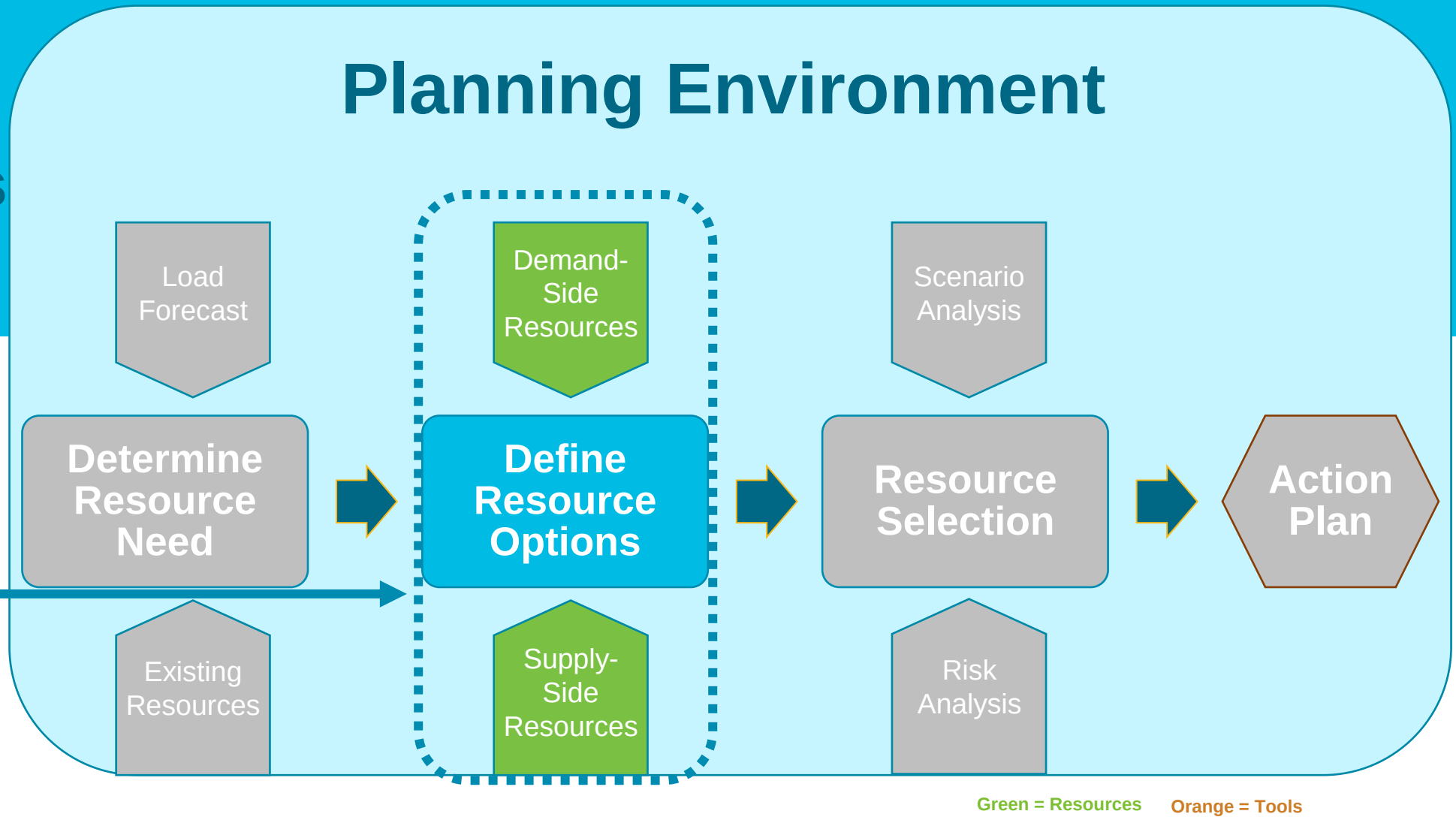
Weather Normalizing Matters



- Past usage and emissions are “noisy,” and will be in the future
- Differences in weather from year to year drive this volatility
- Forecasts are shown for normal weather
- Extrapolations of non-normal weatherized data can be misleading
- NW Natural models weather that adjusts for climate change

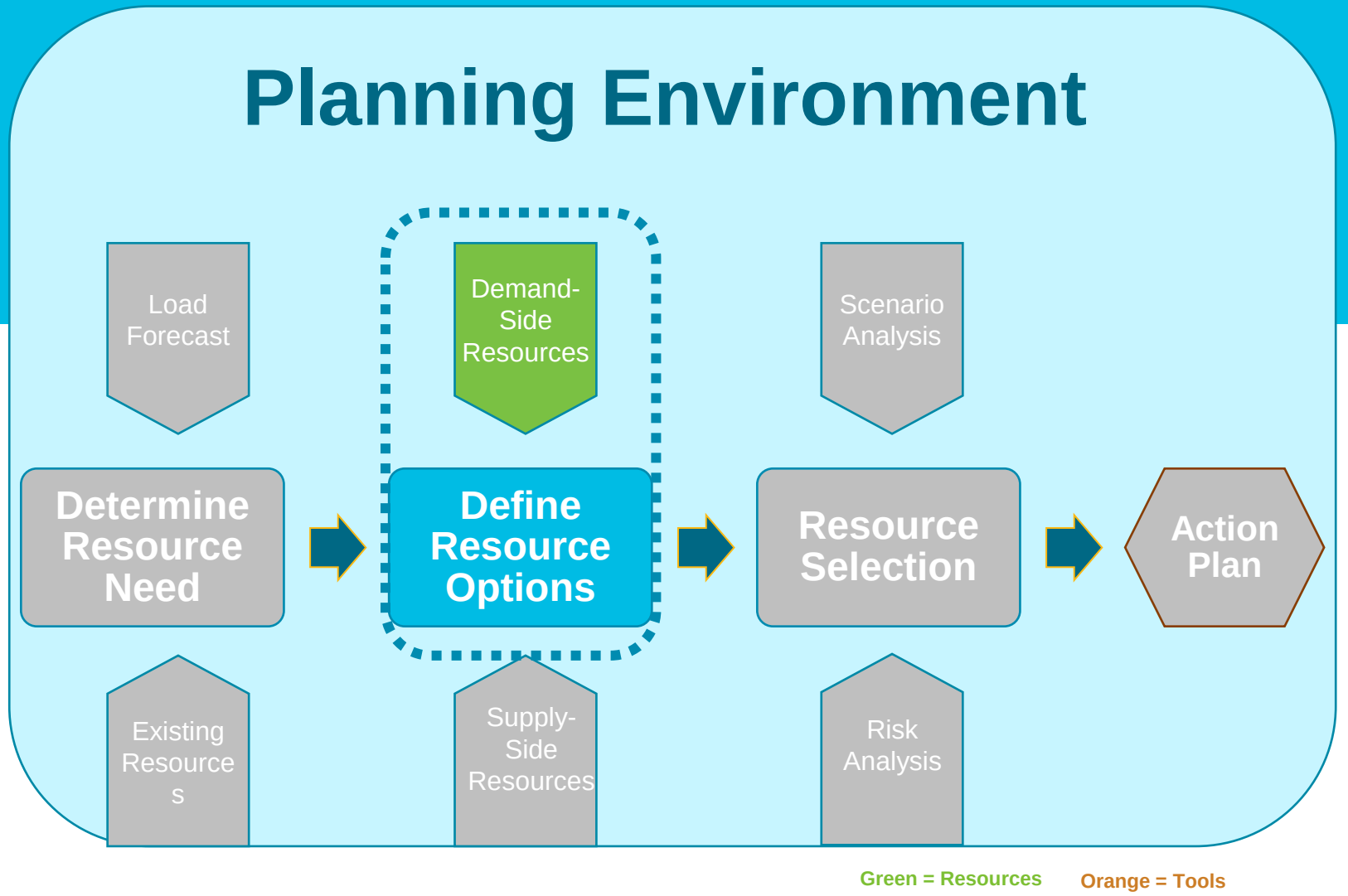
Emission Reduction Opportunities

What emissions reduction options are available?



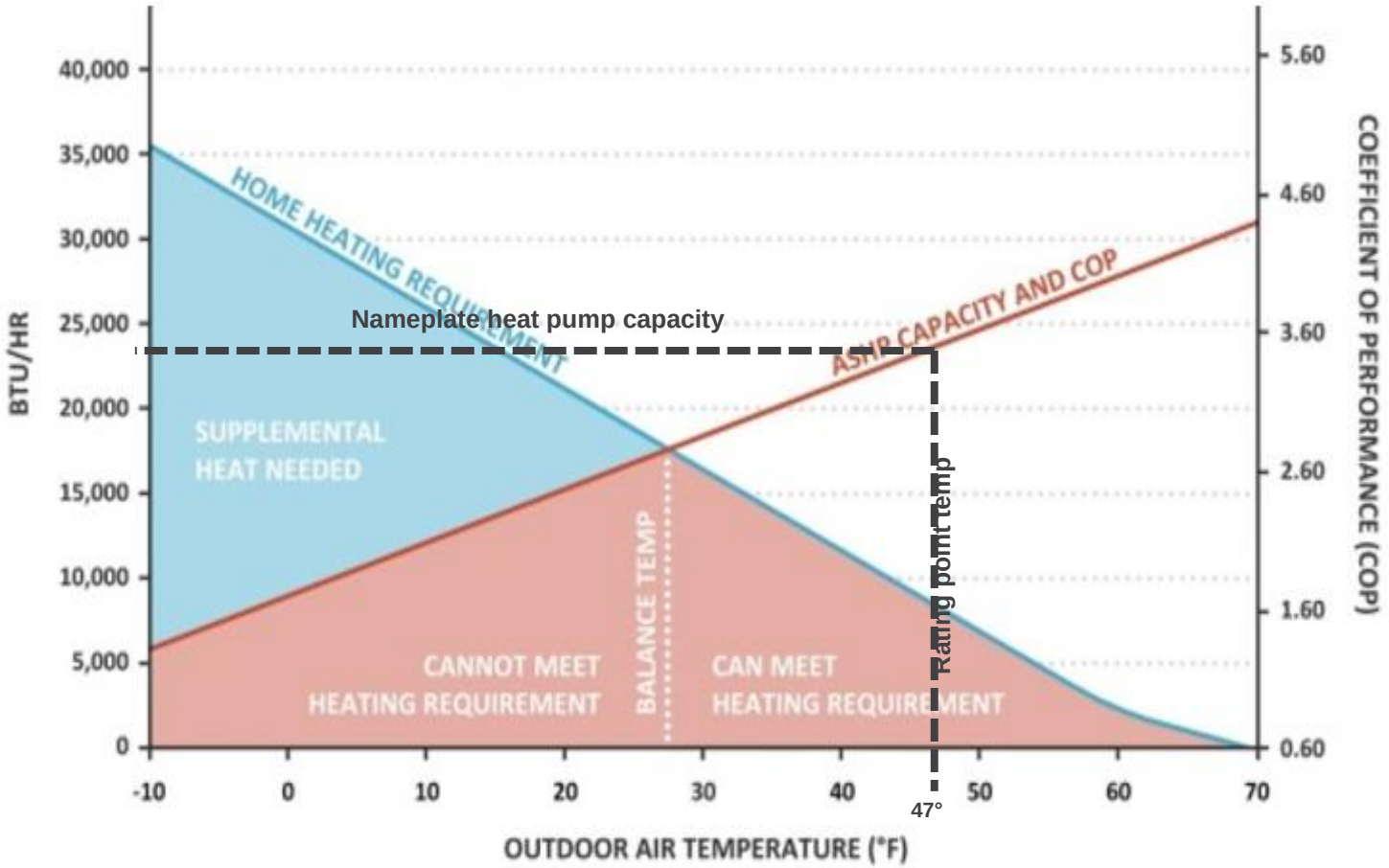
Reducing Usage-
Incremental Demand-Side Emissions Reduction Options

- **Additional Funding for Existing Programs**
- **Industrial Decarbonization**
- **Dual-Fuel Heating System (Electric Heat Pump with Natural Gas Furnace Backup)**
- **Residential and Commercial Natural Gas-Powered Heat Pumps**
- **Commercial Scale Carbon Capture and Utilization**



Dual-Fuel Heat Pumps-

Electric heat pump with direct use natural gas backup furnace for peak periods



- Electric heat pumps are efficient, but efficiencies decline as temperature decreases
- To maximize annual efficiency and maintain comfort electric heat pumps almost always have a backup system for cold temperatures – particularly ducted systems which are dominant in single-family homes
- An electric resistance furnace is the most common cold weather backup if a gas furnace is not used
- A system with electric resistance backup is inefficient during cold periods, which contributes large peaks to utility loads and is expensive for customers

Dual-Fuel Heat Pumps

Benefits:

- Helps energy system resource adequacy
  - Dual-fuel systems serve as demand response for the electric grid
- Allows existing seasonal storage infrastructure to serve peak needs in a region that is capacity constrained
- Are lower cost for customers to run, particularly during cold months
- Avoids use of inefficient electric resistance heating

Challenges:

- Regulatory structure may need modification to make the setup work for customers, installers, and utilities
- Current market structure does not value capacity services across the gas and electric grids
- Incentives to homeowners/business owners and HVAC contractors may need to be reconsidered
- Reduces gas usage within a home by roughly 80% in our climate

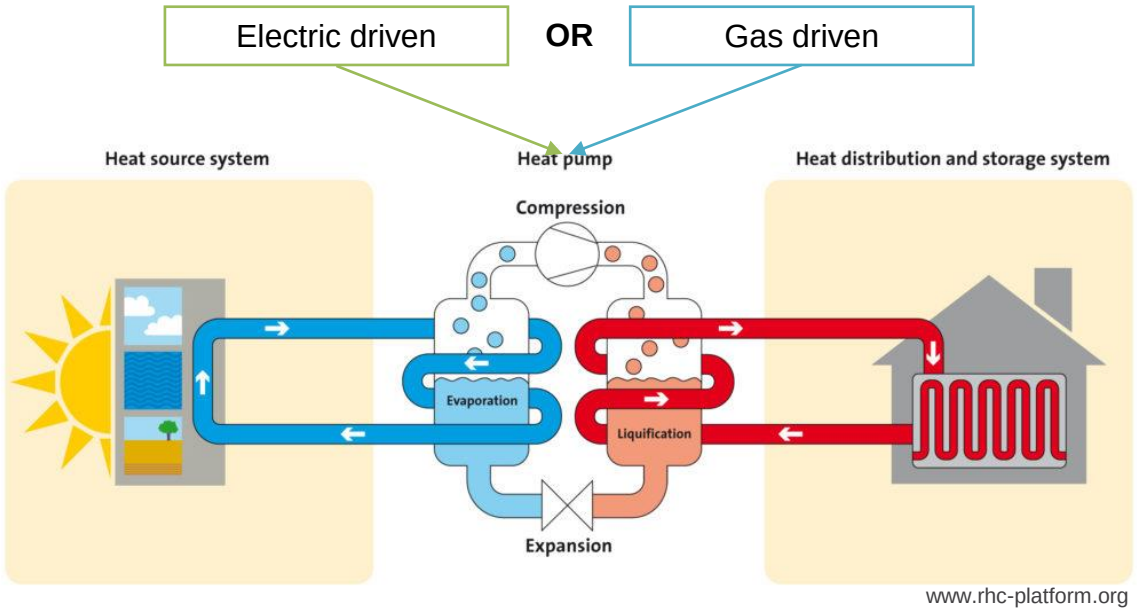
Gas Heat Pumps – GHPs

Heat Pump: Device that moves heat from one location to another; amplifying it in the process

- Many operate reversibly, providing cooling as well

Gas-driven Heat Pump (GHP*): Instead of electricity, GHPs use heat to drive the process

- Based on several technologies
- Driven by gaseous fuels including natural gas, propane, as well as blends using RNG and/or Hydrogen
- Efficient cooling feasible but not always economical
- Many use low-global warming potential refrigerants



*Or “Thermal Heat Pump” (THP)

Performance: Exceeding 100% Efficiency

Demonstration Highlights:

Residential

Water Heater (>1.20 UEF)
- **54% energy savings**[1]

Space and Water Heating/"Combi" (>140% AFUE)
- **45% energy savings**, including operation at -30ºF w/o backup heat[2]

Commercial

Hot Water/Boiler (>130% TE)
- **53% therm savings** (hot water) *and* 14% kwh savings w/A/C[3]

Internal combustion engine driven VRF (>1.50 $COP_{heating}$ >1.40 $COP_{cooling}$)
- Successful operation in both warm and cold climates[4]

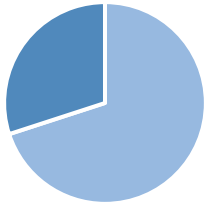
Rooftop Unit (>1.30 $COP_{heating}$ @ 47ºF)
- Cold-climate testing indicates only 5% capacity reduction at 5ºF[4]

For more information: 1) Glanville, P.et al. (2020) Integrated Gas-fired Heat Pump Water Heaters for Homes: Results of Field Demonstrations and System Modeling, ASHRAE Transactions; Vol. 126 325-332.; 2) Glanville, P. et al. (2019) Demonstration and Simulation of Gas Heat Pump-Driven Residential Combination Space and Water Heating System Performance, ASHRAE Transactions; Vol. 125 264-272.; 3) Glanville, P. Innovative Applications of Thermal Heat Pumps in Multifamily Buildings and Restaurants, Presented at the ACEEE 2020 Hot Water Forum.; 4) GTI & Brio, Gas Heat Pump Technology and Market Roadmap, 2019.

North American GHP Collaborative

…developing and implementing activities to accelerate adoption of gas heat pump technologies

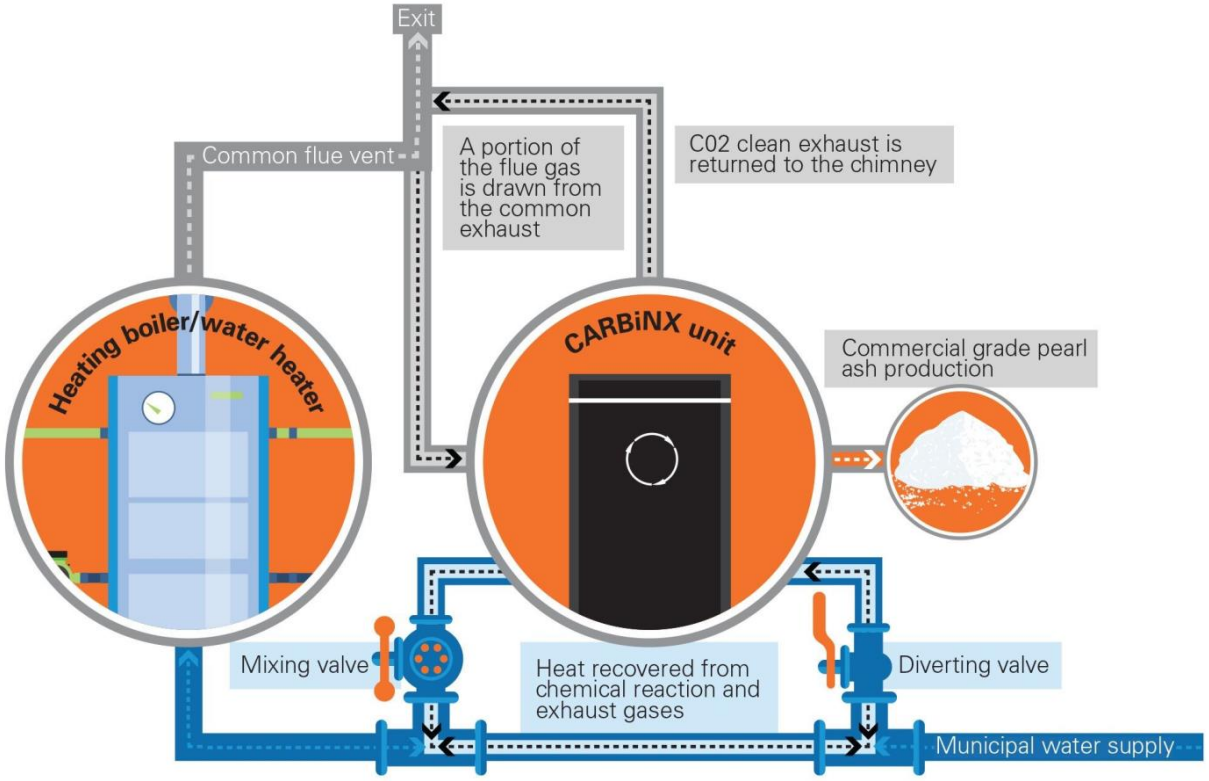
- Working with manufacturers to develop **product launch strategies**
- Conducting **market research** to inform supply chain business decisions and utility market interventions
- Adopting joint **product specifications** to ensure customer satisfaction and product performance
- Supporting **supply chain education** to prepare the market
- Offering **aligned incentives** on qualified products to drive adoption
- Working with standards-setting organizations to incorporate GHPs into **codes and standards**



Representing >30% of US and Canadian households that use gas

Carbon Capture and Utilization

- Identified technology out of Canada- provides heat recovery and carbon capture, converted to soap or fertilizer
- CleanO2 produces CARBiN-X - ideal for boilers using 240k – 1.5 million Btu/hr
- Capture rates:
  - Current: 20%
  - 2022 V4 anticipated to capture 40%
  - 2028 planning for a 100% capture model that will be commercially available in 2030
- 2021-2022 NWN piloting 3 units, modeled after peer utility pilots



Key Demand-Side Assumptions

- Cost and savings of high ramp/high CO2 cost sensitivity from Energy Trust of Oregon analysis applied in all scenarios
- History and cost trajectory of large commercial and industrial energy efficiency on sales schedules applied to transport schedule loads
- Starting in 2025 30% of HVAC systems installed (both in new construction and replacement on burnout) are dual-fuel systems
- Starting in 2025 25% of HVAC and water heating systems installed (both in new construction and replacement on burnout) are natural gas heat pumps

Incremental Demand-Side Measure Costs	Incentive	Total Cost to Utility
Residential Hybrid Heating Incremental Incentive (2020$/System Install)	$1,200	$1,600
Residential Hybrid Heating Share of Incentive paid by non-CCI funds (%)	25%	$400
Residential Gas Heat Pump Incentive (2020$/System Install)	$3,000	$4,000
Residential Gas Heat Pump Water Heater Incentive (2020$/System Install)	$1,200	$1,600
Commercial Hybrid Heating Incremental Incentive (2020$/System Install)	$3,000	$4,000
Commercial Hybrid Heating Share of Incentive paid by non-CCI funds (%)	25%	$1,000
Commercial Gas Heat Pump Incentive (2020$/System Install)	$10,000	$13,333
First Year High Ramp Incremental Cost (2020$/1st year therm saved)		$5.06
First Year Transport Load Savings Cost (2020$/1st year therm saved)		$1.79

Decarbonizing Gas

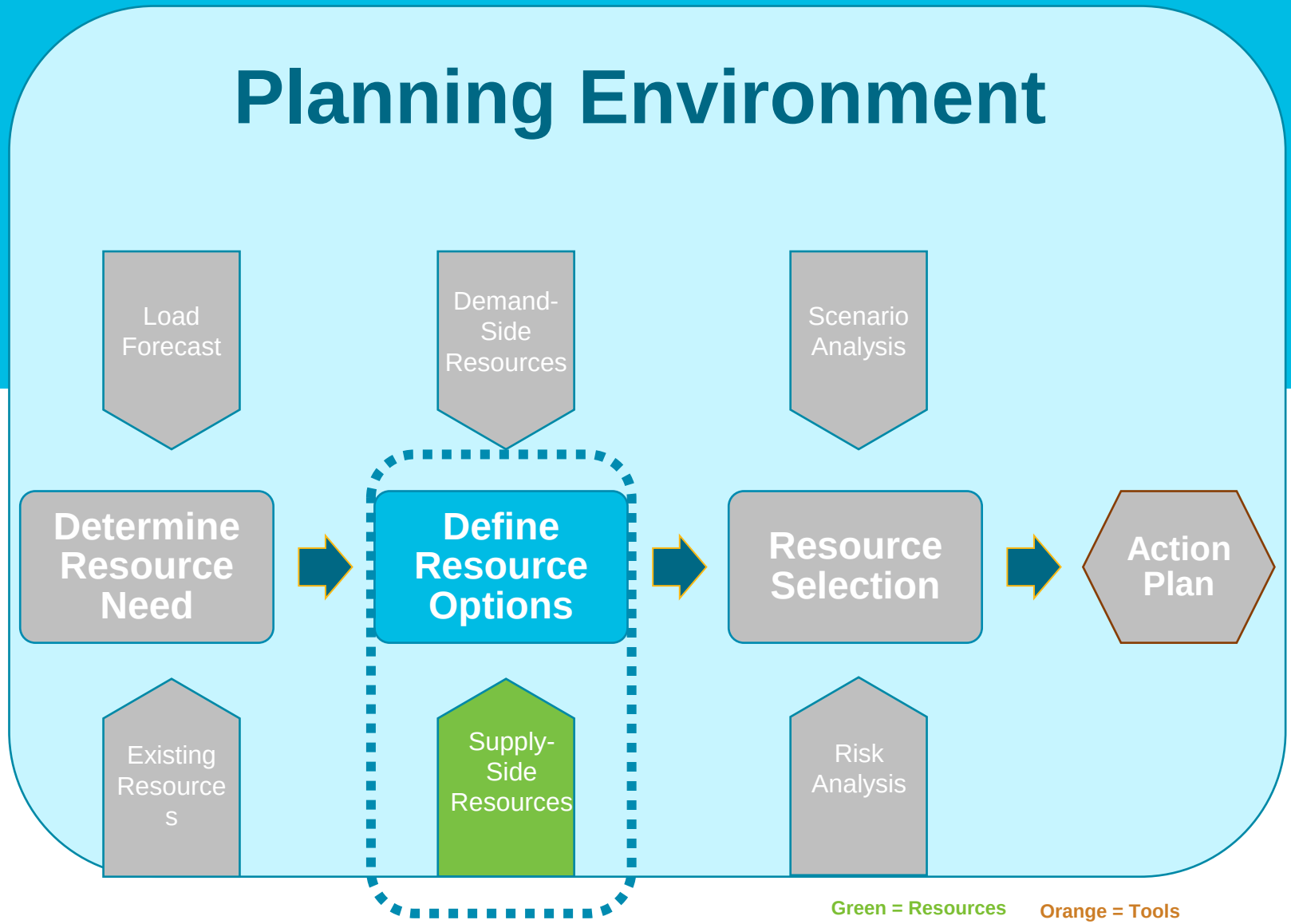
Incremental Supply-Side Emissions Reduction Options

Renewable Natural Gas

- **Biofuels**
- **Clean Hydrogen**
- **Synthetic Renewable Gas**

Carbon Capture

- **Storage**



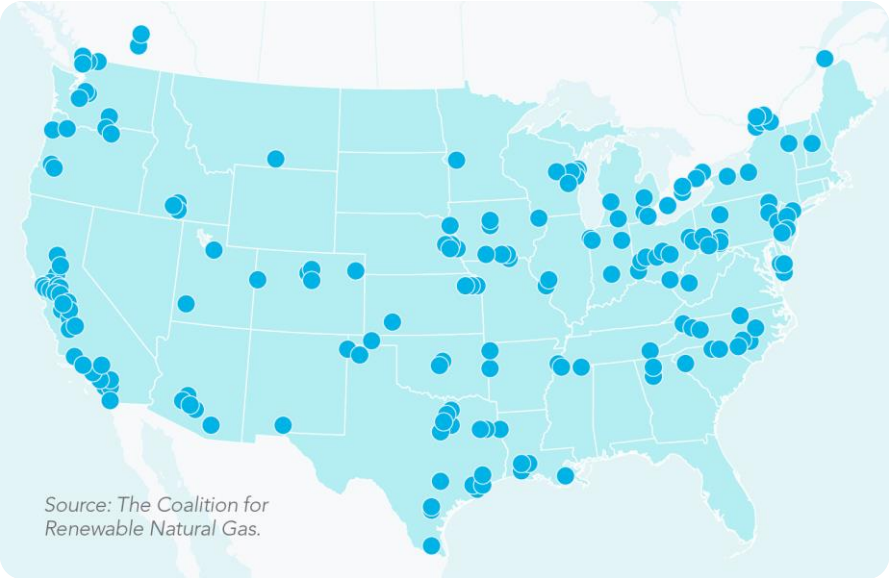
Biofuel RNG as a Resource

- Derived from waste methane resources from:
  - Landfills
  - Wastewater treatment plants
  - Agricultural wastes (e.g., corn stover)
  - Animal manures
  - Waste biomass
- Main components of an RNG project:
  - Raw gas production/capture (e.g., anaerobic digester or landfill gas well system)
  - Gas conditioning and cleaning system (removes various impurities and other gases to ensure RNG is pipeline quality)
  - Compressor (if needed)
  - Interconnection to local gas pipeline

Nitrogen removal system for large landfill RNG project

Membranes to clean RNG at Tyson Lexington facility (NW Natural project)

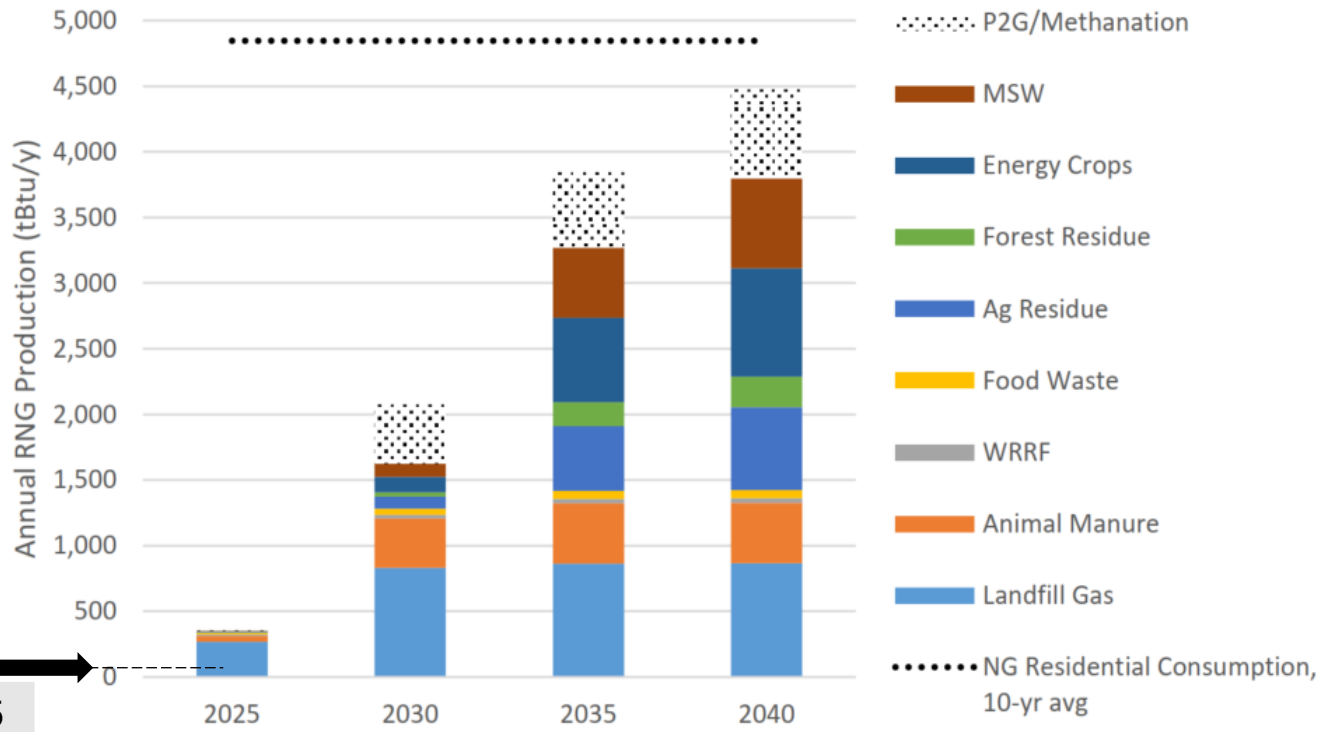
Current State of the RNG Market: Supply



- **188 operational RNG projects**
- **137 under development**
- **359% increase in operational RNG projects since 2014**

Today's RNG supply: 55 Trillion btus/year

Figure 2. Estimated Annual RNG Production, High Resource Potential Scenario, tBtu/y



Source: 2019 American Gas Foundation Study Prepared by ICF

Role of Utilities and Large Gas Customers in the RNG Market

- RNG has historically been sold into highly lucrative but highly volatile transportation fuel markets
- RNG project developers have less confidence in the stability of these markets and are seeking reliable long-term contracts at fixed prices to help hedge their revenue risks
- Natural gas utilities, large industrial users, and large institutional gas users are beginning to sign more long-term contracts for RNG to meet decarbonization goals
- Fixed-price contracts for RNG often represent a large portion of the total RNG produced by an RNG facility, but not all RNG produced; the project owner may sell a small portion of the RNG into the lucrative transportation markets
- Natural gas utility and large customer purchases of RNG provide an important "floor" price for RNG projects, which has helped RNG projects secure more affordable financing

- 15-year contract with Archaea
- Landfill gas
- For heating and on-campus power generation
- Goal: carbon neutral by 2050

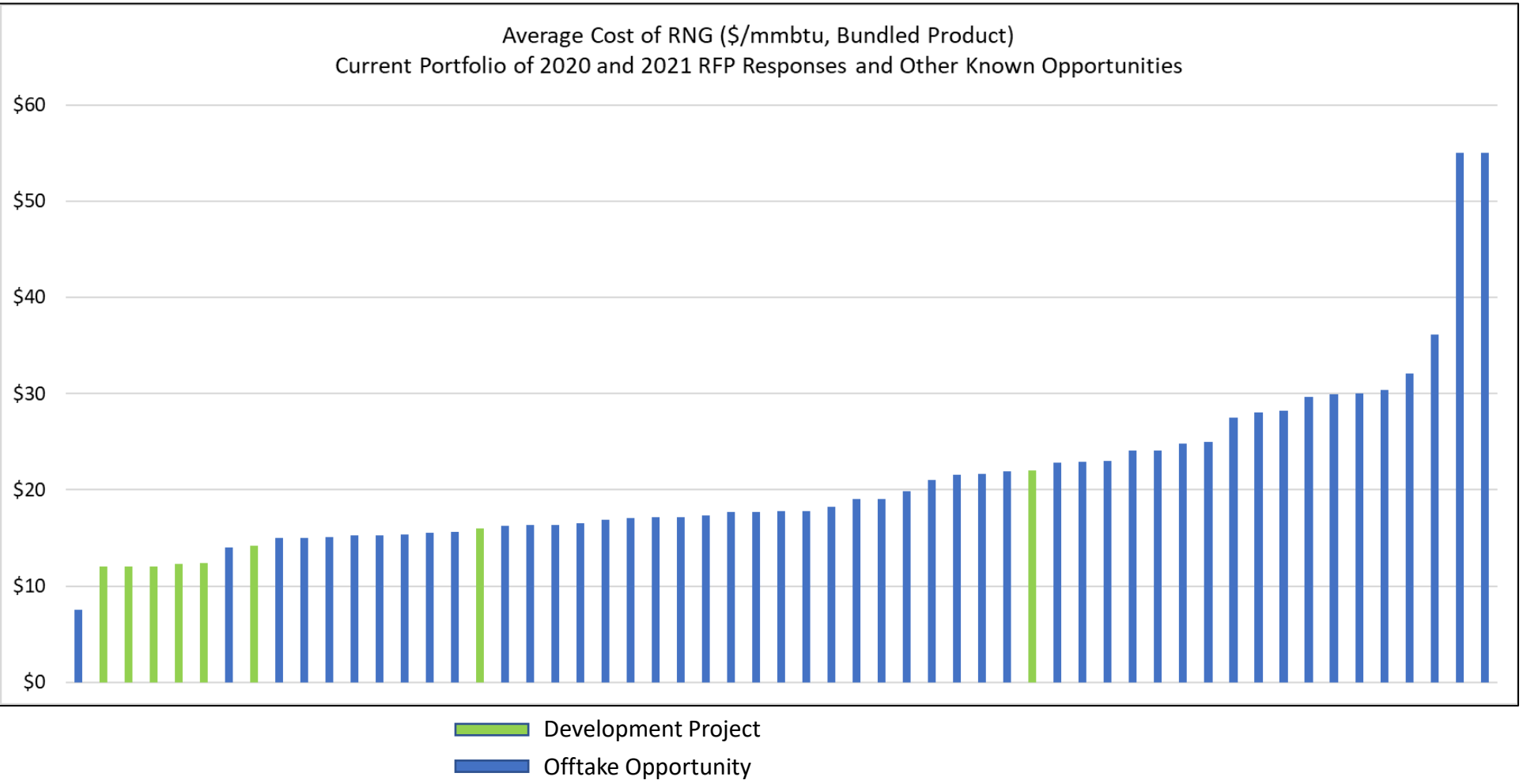
- 10-year contract with US Gain
- For heating and CNG vehicles use
- Goal: reduce carbon emissions 50

- 15-year contract with Big Run Landfill
- For on-site manufacturing at multiple locations
- Goal: carbon neutral by 2025

NW Natural's RNG Market Activity

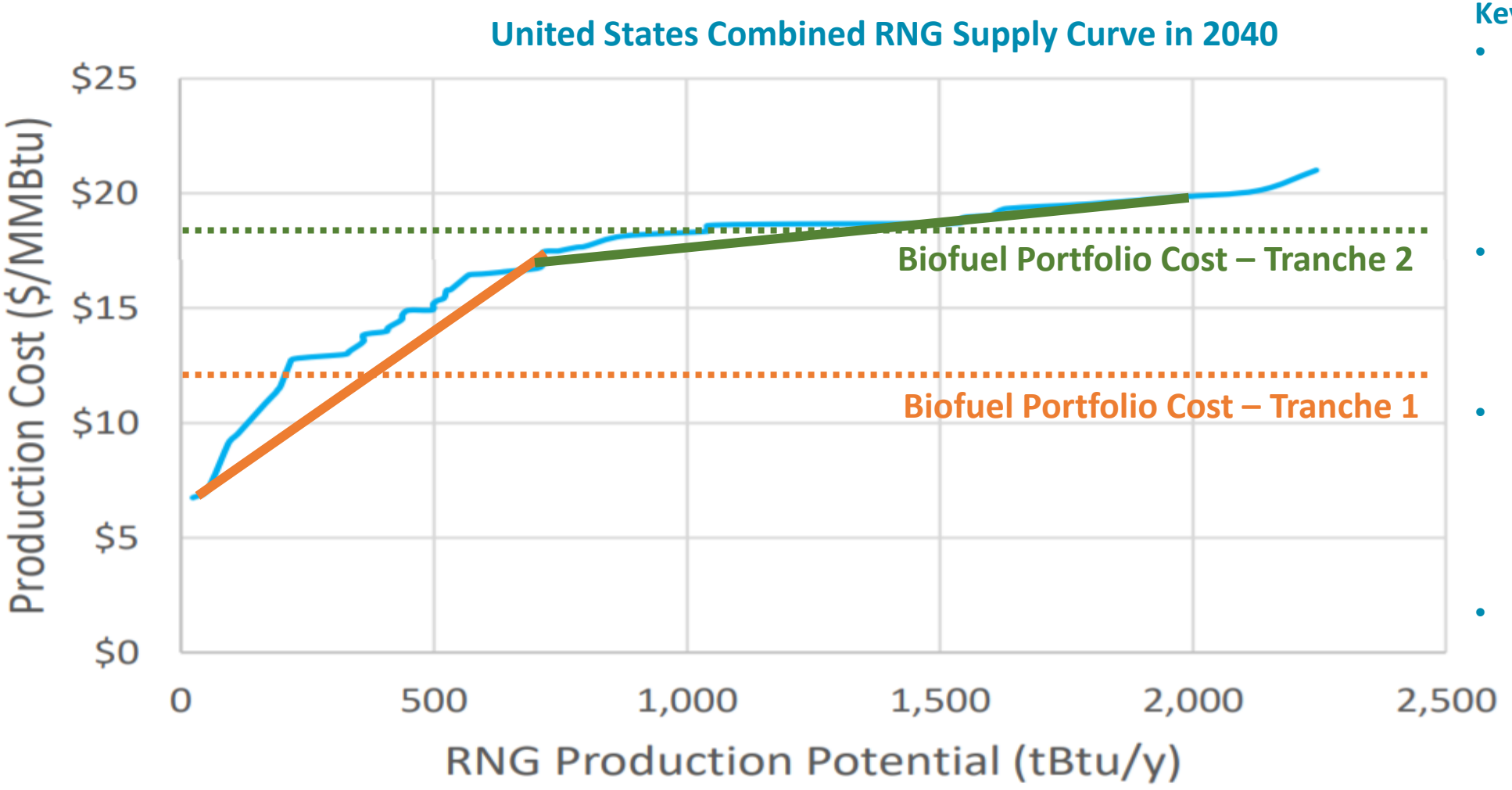
- **2020: began issuing annual RFPs for RNG Supply – first gas utility in the country to issue RFPs seeking RNG for all customers**
  - 2021 RFP yielded a "short list" of RNG resources available in the near term totaling 11% of our Oregon sales volume; currently conducting additional diligence on short list opportunities
  - 26 individual proposals received in 2021 process
  - High interest from developers and RNG project owners in long-term fixed price contracts
  - Regularly contacted in between RFP cycles with offers of RNG to meet S.B. 98 targets
- **Project development team working to develop low-cost RNG resources**
  - Development projects consistently evaluated as lower incremental cost than offtakes available through RFP processes and market outreach
  - Tyson, Lexington RNG project: began construction earlier this month; expected to be operational by early 2022
  - Project team continues to evaluate additional project opportunities that yield projected incremental costs of less than offtake-only opportunities
- **Executing first offtake contracts for RTCs as a result of 2020 RFP**
  - Executed contract with Element Markets for RNG from two facilities
  - Second contract currently being finalized

Significant RNG Resources Available and Currently Under Evaluation



- Chart reflects 2020 and 2021 RFP responses, as well as the development projects NW Natural is currently evaluating
- Total production represented in this chart: 35.3 million mmbtu/year, or about 49% of all of NW Natural's annual sales in Oregon in 2021

Biofuel RNG Assumptions



Key Assumptions:

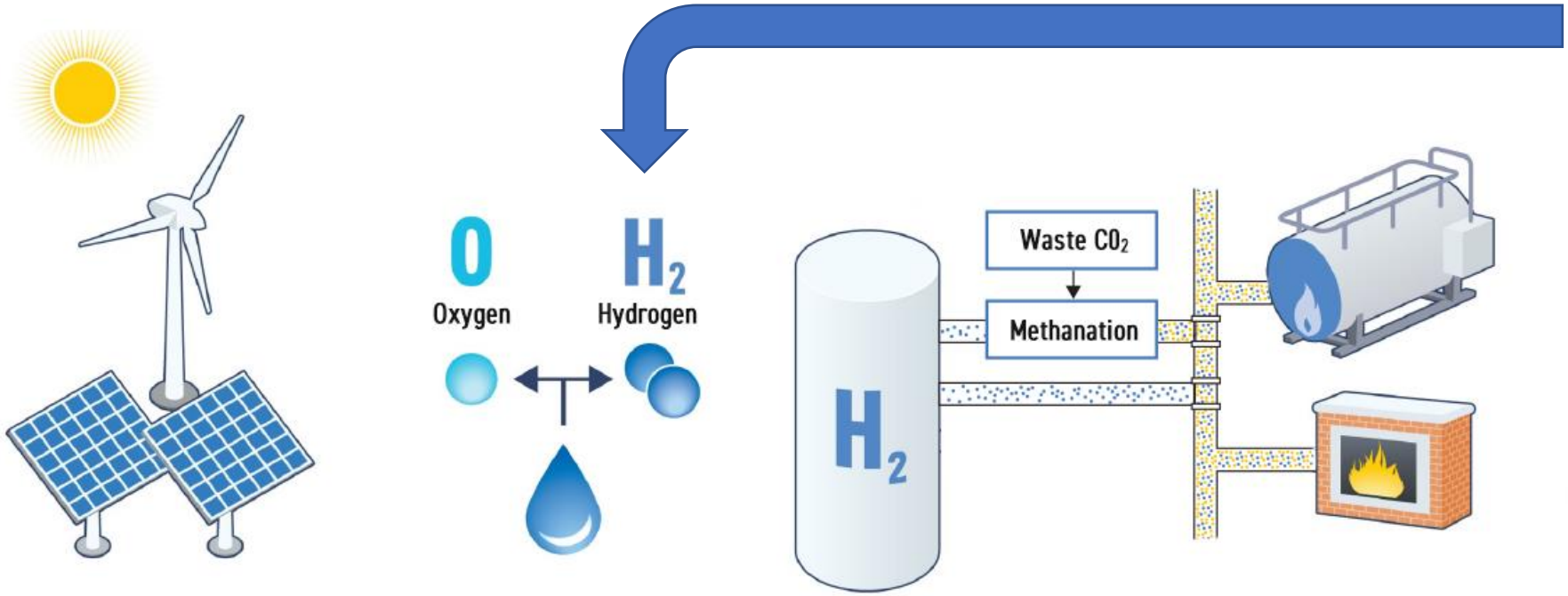
- Maximum available RNG to Oregon's gas utilities is double the population weighted share of the national resource
- RNG Resources are not all available at all times, so using a traditional supply curve is inappropriate
- 1/3 of available resource (~15 million MMBtu per year for NW Natural) can be acquired for a portfolio cost of $12.25/MMBtu
- The remaining 2/3 of the resource (~31 million MMBtu) can be acquired for a portfolio cost of $18.75/MMBtu

Supply Curve Source: "Renewable Source of Natural Gas." American Gas Foundation Study Prepared by ICF (2019)

Hydrogen Benefits

Needed as key component of carbon-free future	No reasonable pathway to decarbonizing without hydrogen
Fits into current gas operations	Distribution | Storage | Customer Appliances
Numerous sources	Electricity | Biomass | Natural gas
Pathway to decarbonize hard to decarbonize sectors	Aviation, transportation, industry, marine

Electrolysis / Power to Gas / Green H_2

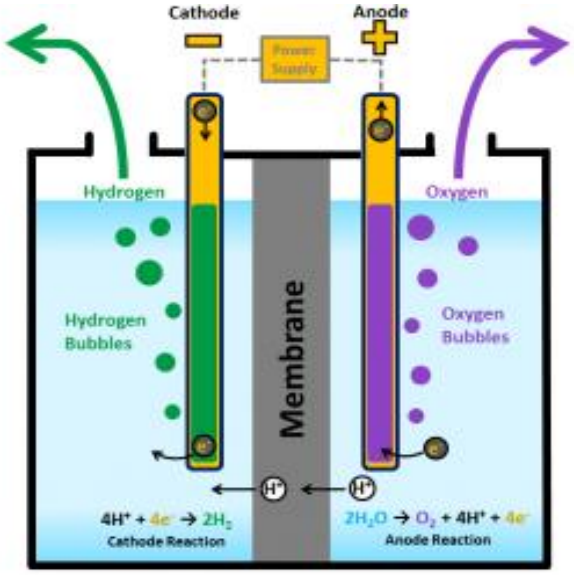


Wind and solar energy that can't be stored

Goes through electrolysis which splits the molecule

Can be blended as hydrogen directly into the pipeline or combined with waste carbon to create renewable natural gas

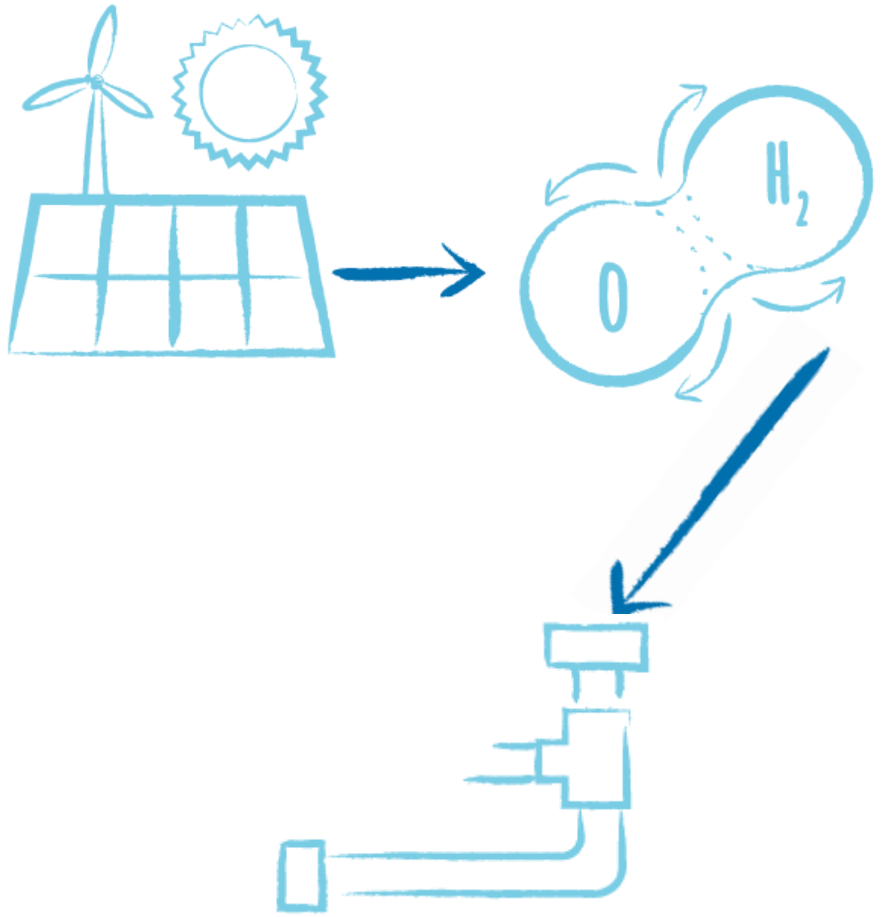
Can be used immediately or stored seasonally for future use



Source: DOE

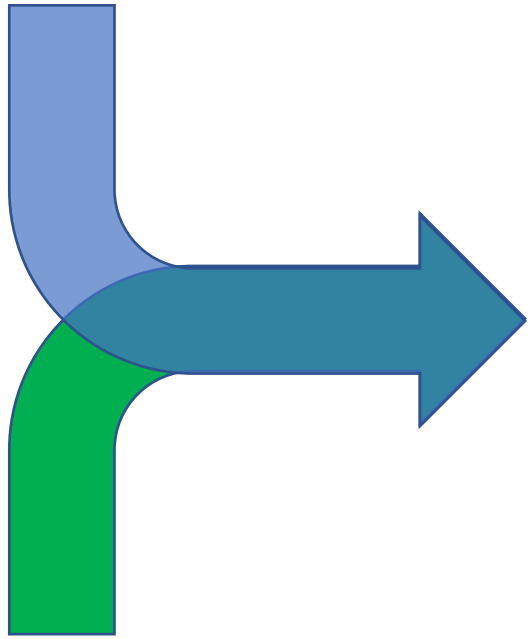
Green Hydrogen

- Takes advantage of curtailed renewables
- Provides grid benefits (ancillary services) to lower rates
- Simple messaging
- Lower capital cost to methanated hydrogen
- Limitations
  - Blend % limits (system and appliance compatibility)
  - Small scale
  - No transmission injection options



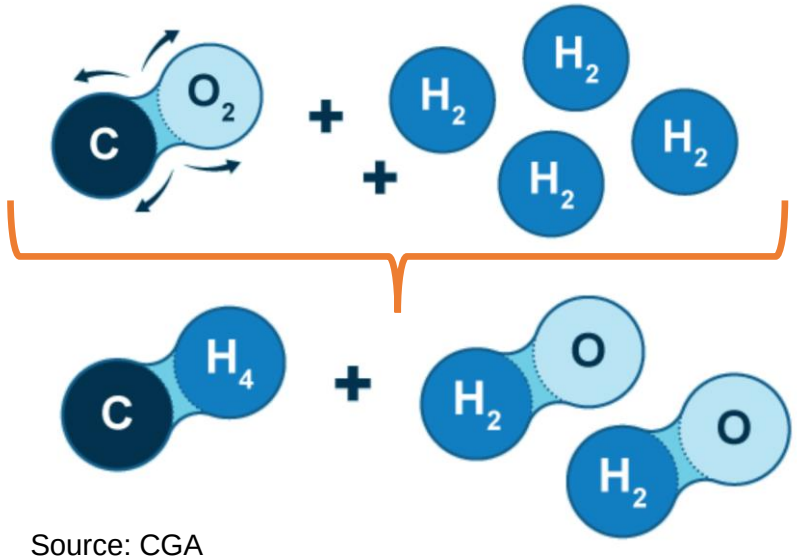
2021 Blending Projects

Enbridge (Toronto)	2%, construction started
ATCO (Edmonton)	5%
CenterPoint (Minneapolis)	1MW electrolyzer, construction started
NJNJ	< 1 MW electrolyzer, construction started
HyDeploy (Keele University, UK)	20% blend wrapping up
H21 – UK	100% hydrogen network underway



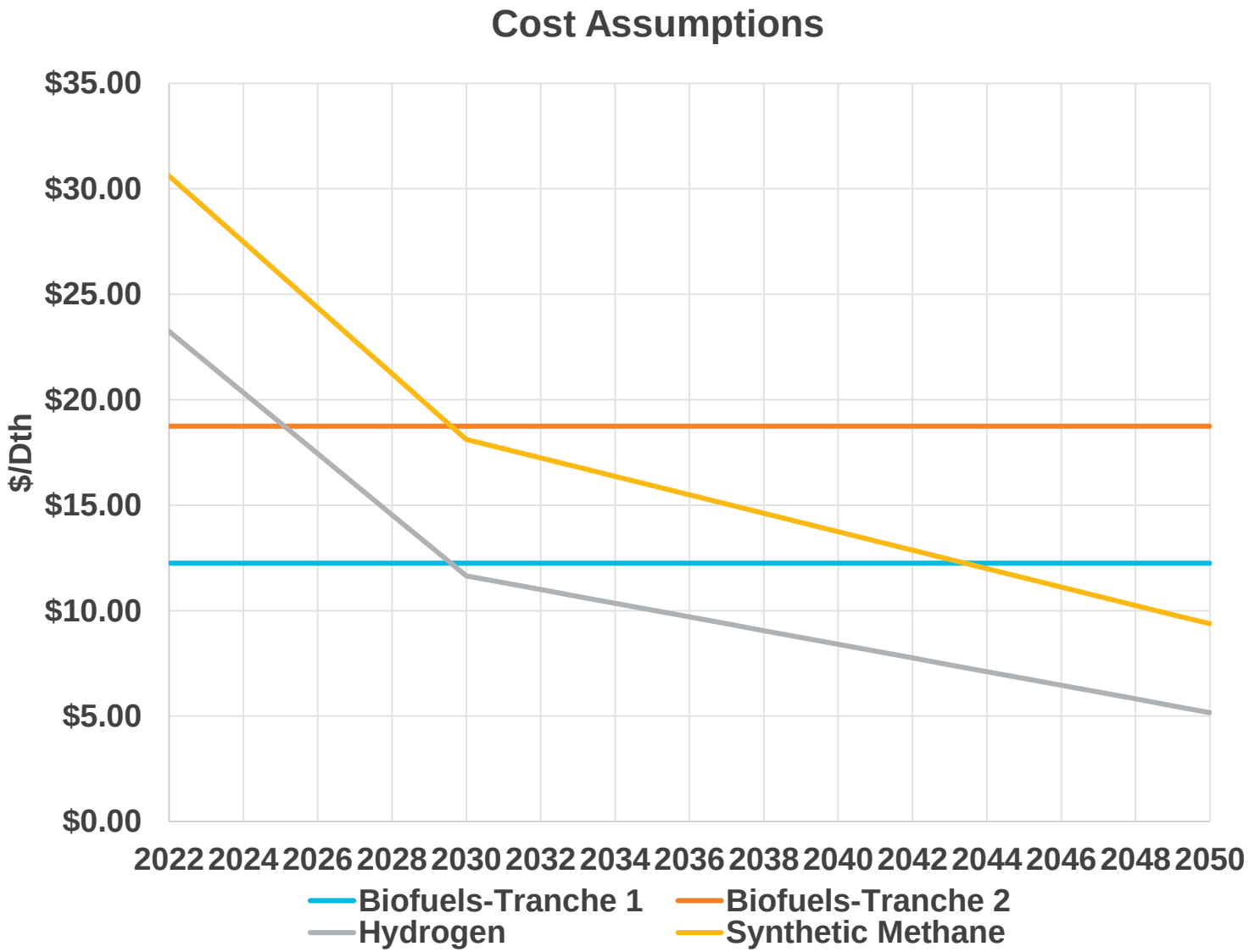
Methanated Green Hydrogen (Synthetic Gas)

- Identical electrolytic hydrogen generation as previously described
- Similar costs to green hydrogen even with lower efficiency
    - Enables high electrolyzer utilization
    - Enables large scale production plants
- No blending % limit (system and appliance compatibility)
- No system energy delivery loss
- Need steady and low-cost supply of CO_2



Source: CGA

Total Renewable Gas Supply Curve



Hydrogen data sources: Bloomberg

Availability Assumptions

Renewable Supply Type	Max Supply Available to NW Natural
Biofuel RNG Tranche 1	15.4 Million MMBtu
Biofuel RNG Tranche 2	30.7 Million MMBtu
Green Hydrogen for Blending	20% of Deliveries
Synthetic Gas from Green H2	Unlimited

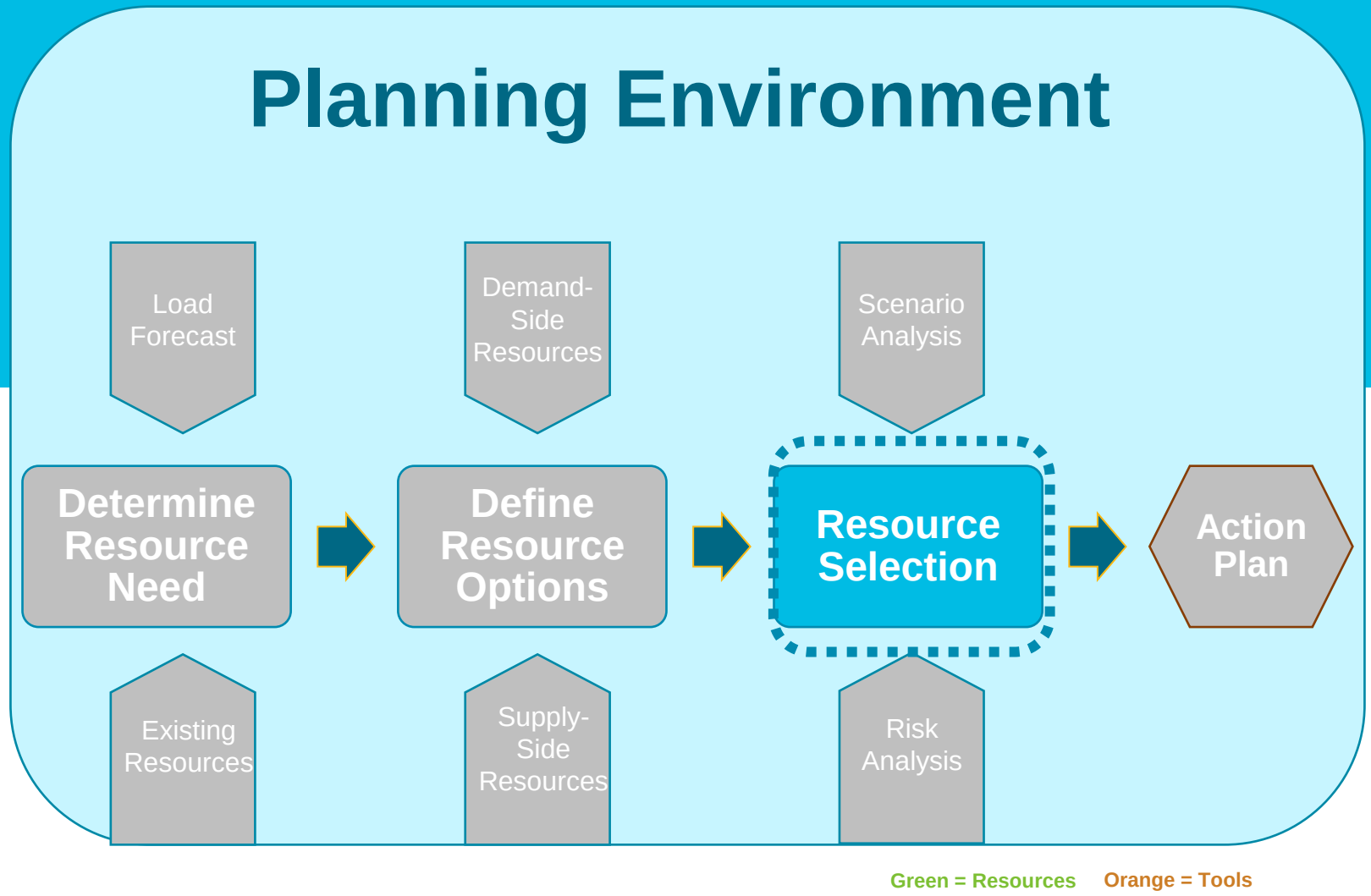
Drivers of Cost Reductions

- Lower cost renewable power
- Continued declines in equipment costs
- Growing global supply of hydrogen

What might compliance look like?

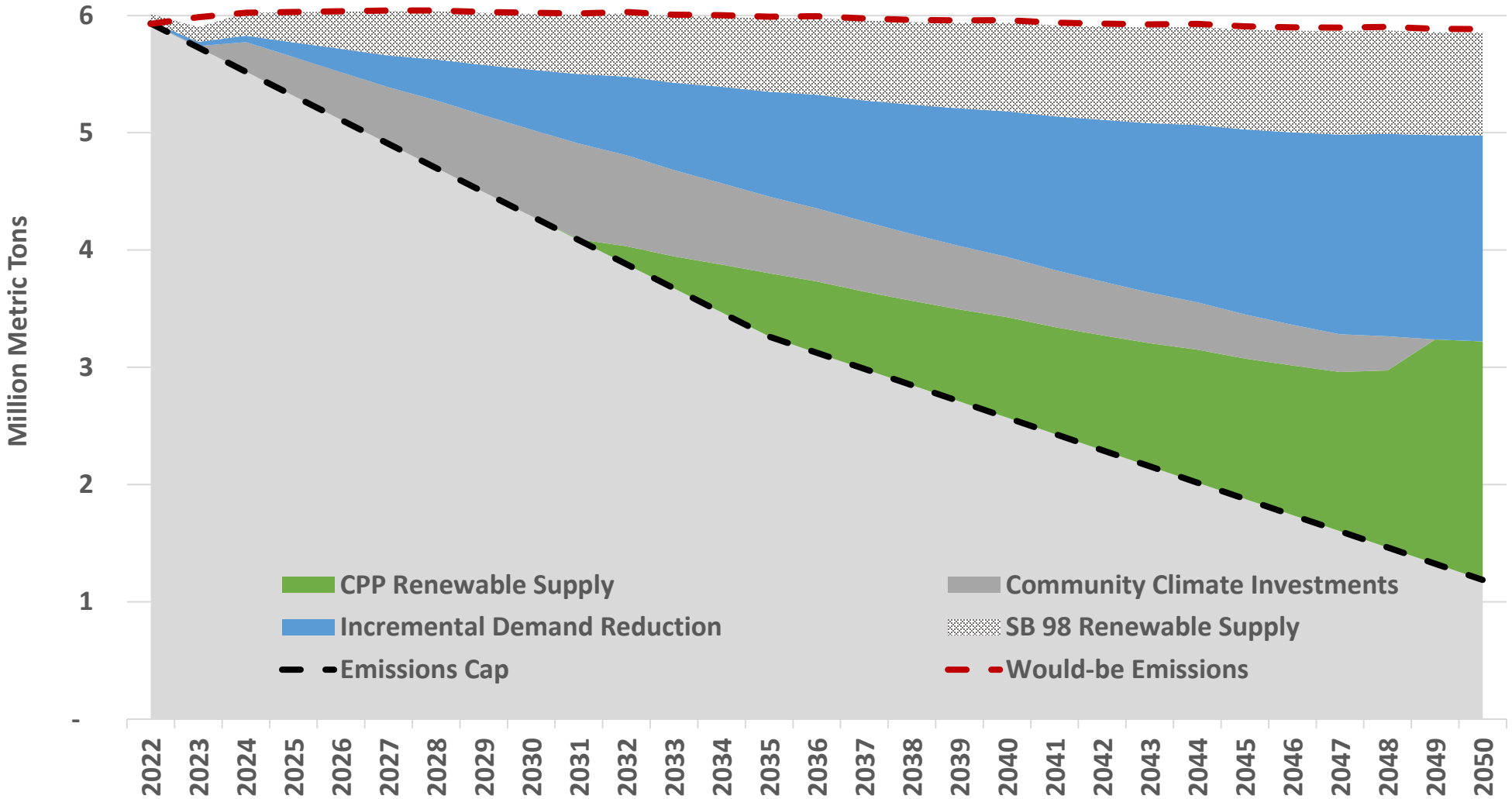
Reminders:

- **This analysis does not apply the robust tools used in IRP planning**
- **The CPP rules are a draft and still under consideration**
- **The best options for customers are likely to evolve as time moves forward and technologies progress**

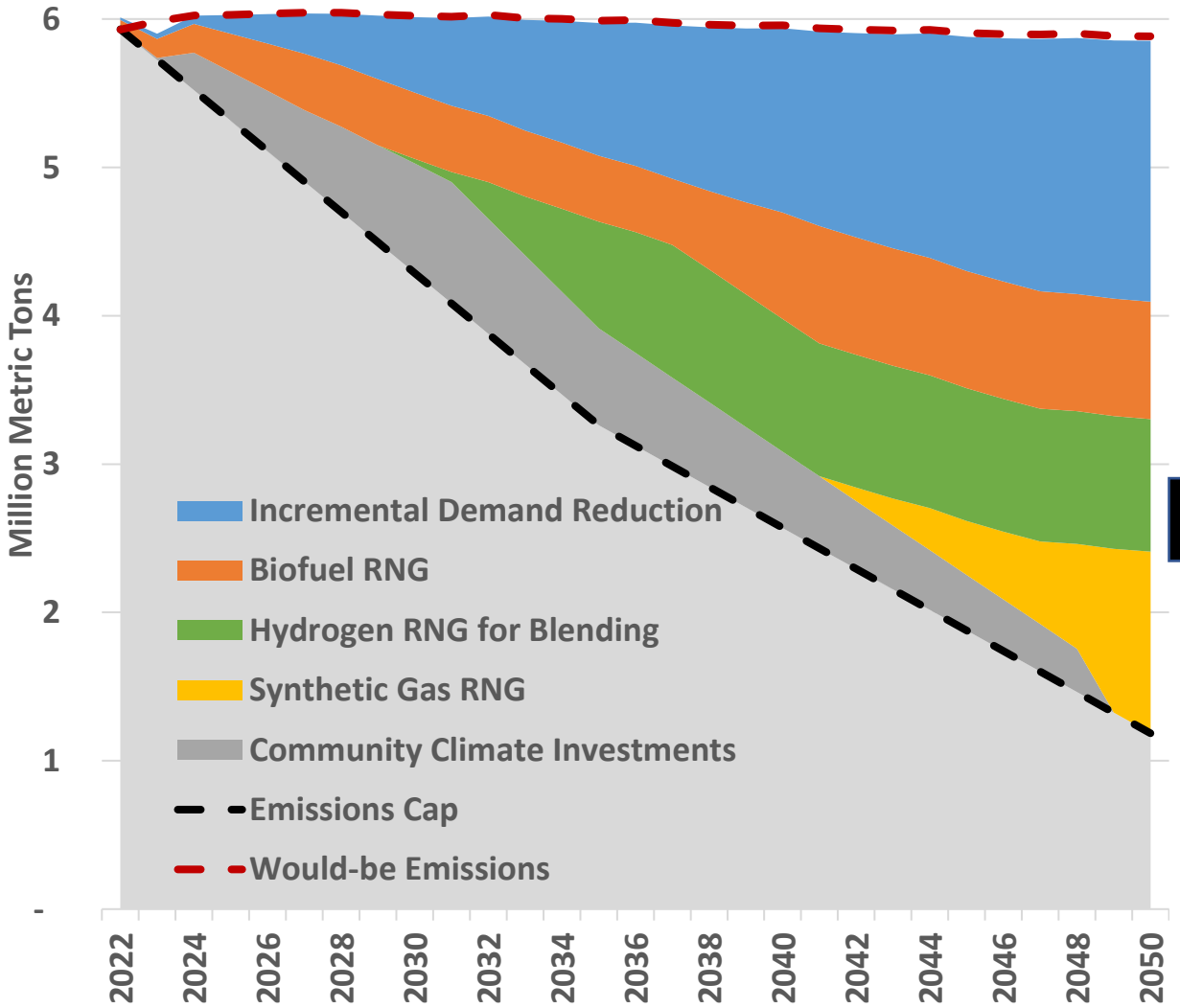


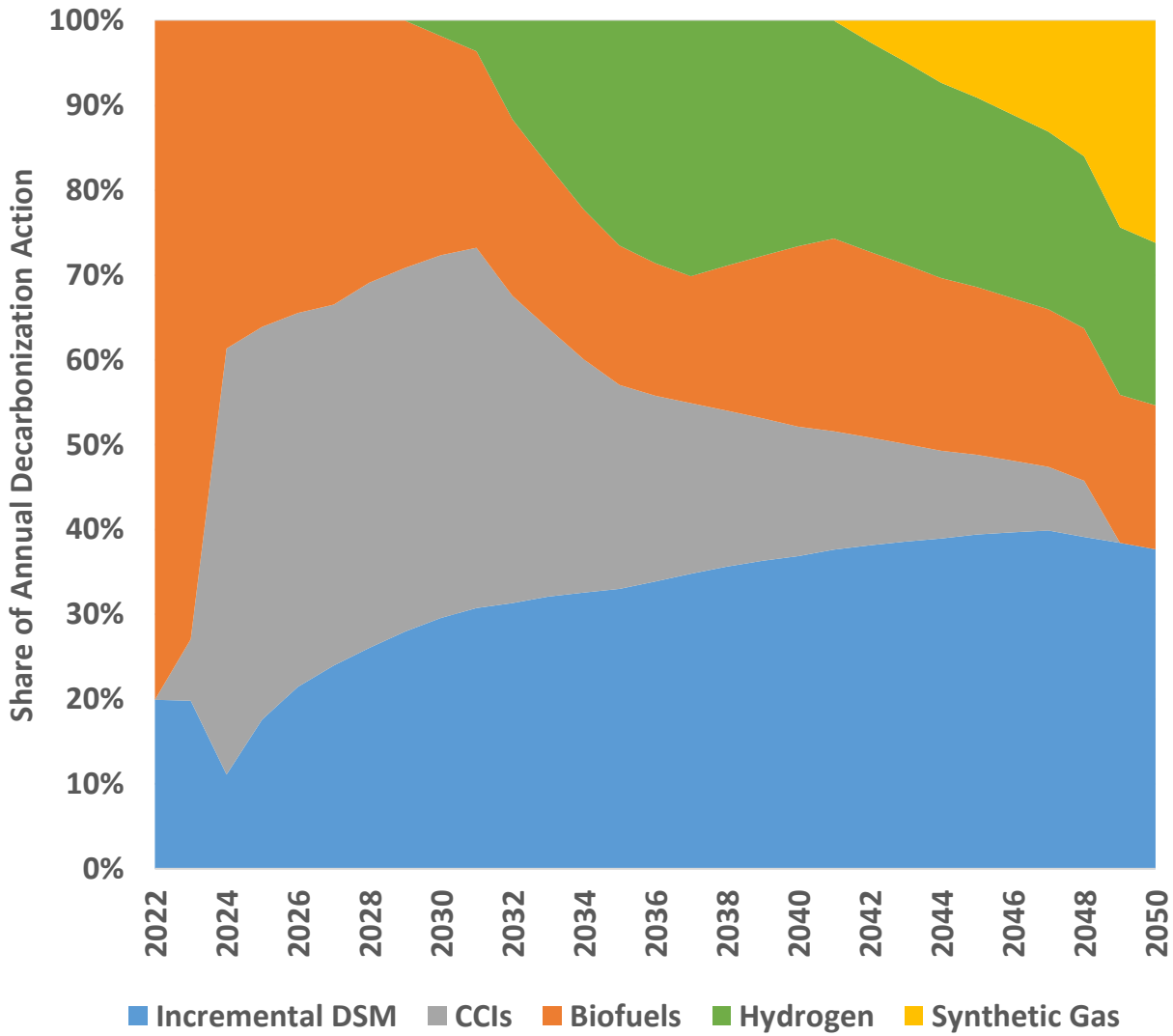
What incremental actions could be taken to comply with the CPP?

Draft CPP Compliance Strategy Summary

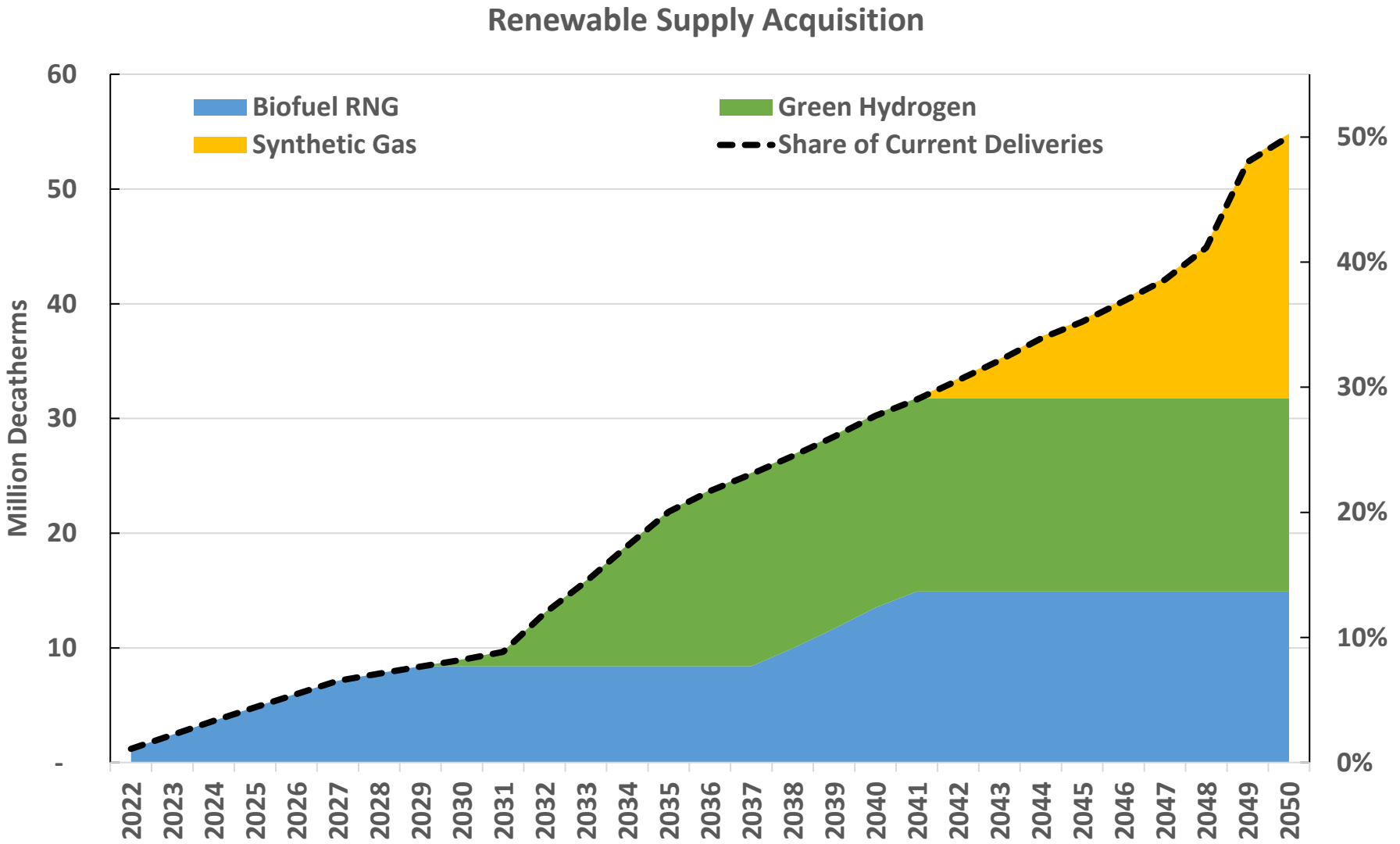


Draft CPP Compliance Strategy Summary



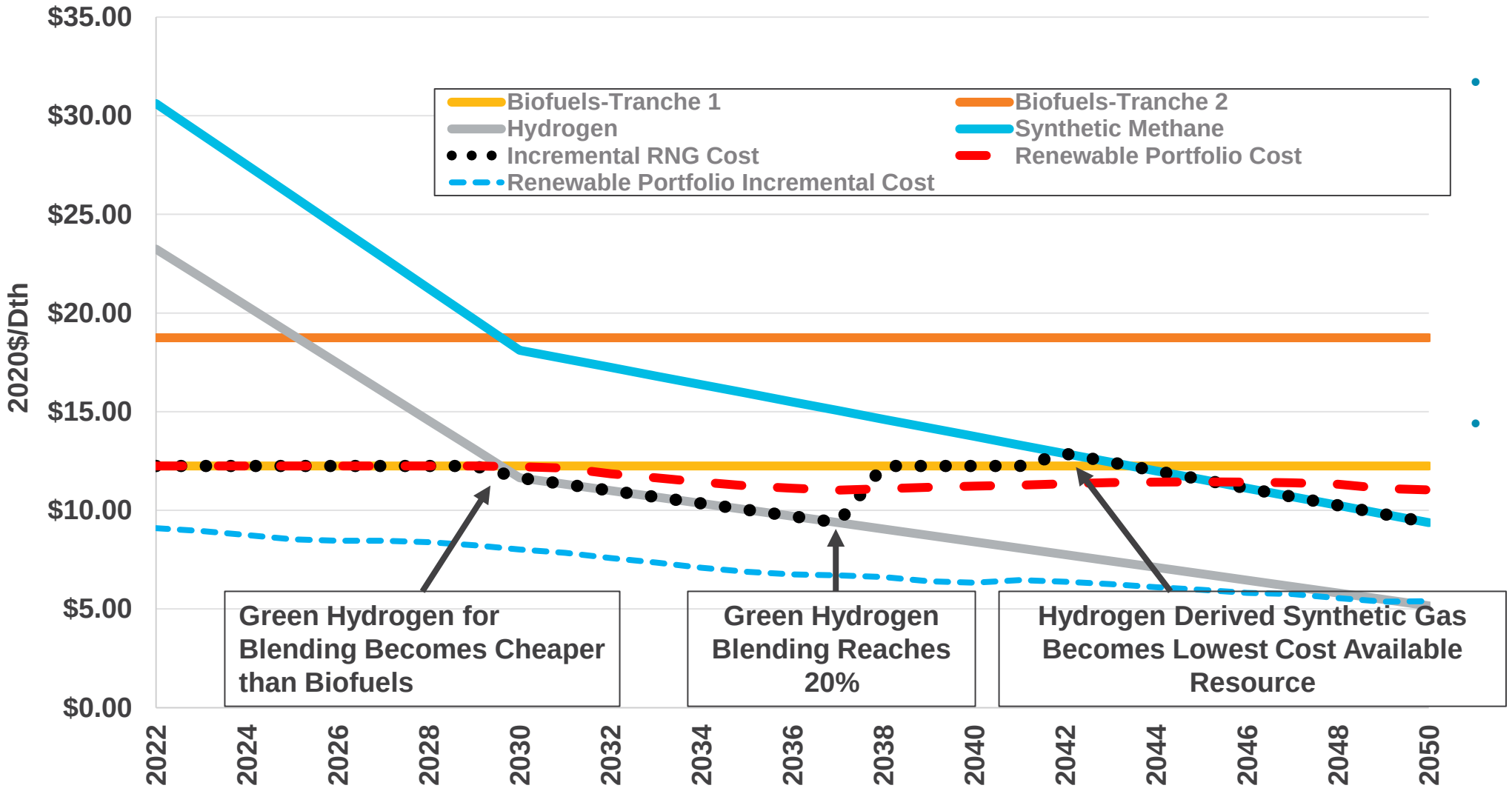


Draft Renewable Supply Results



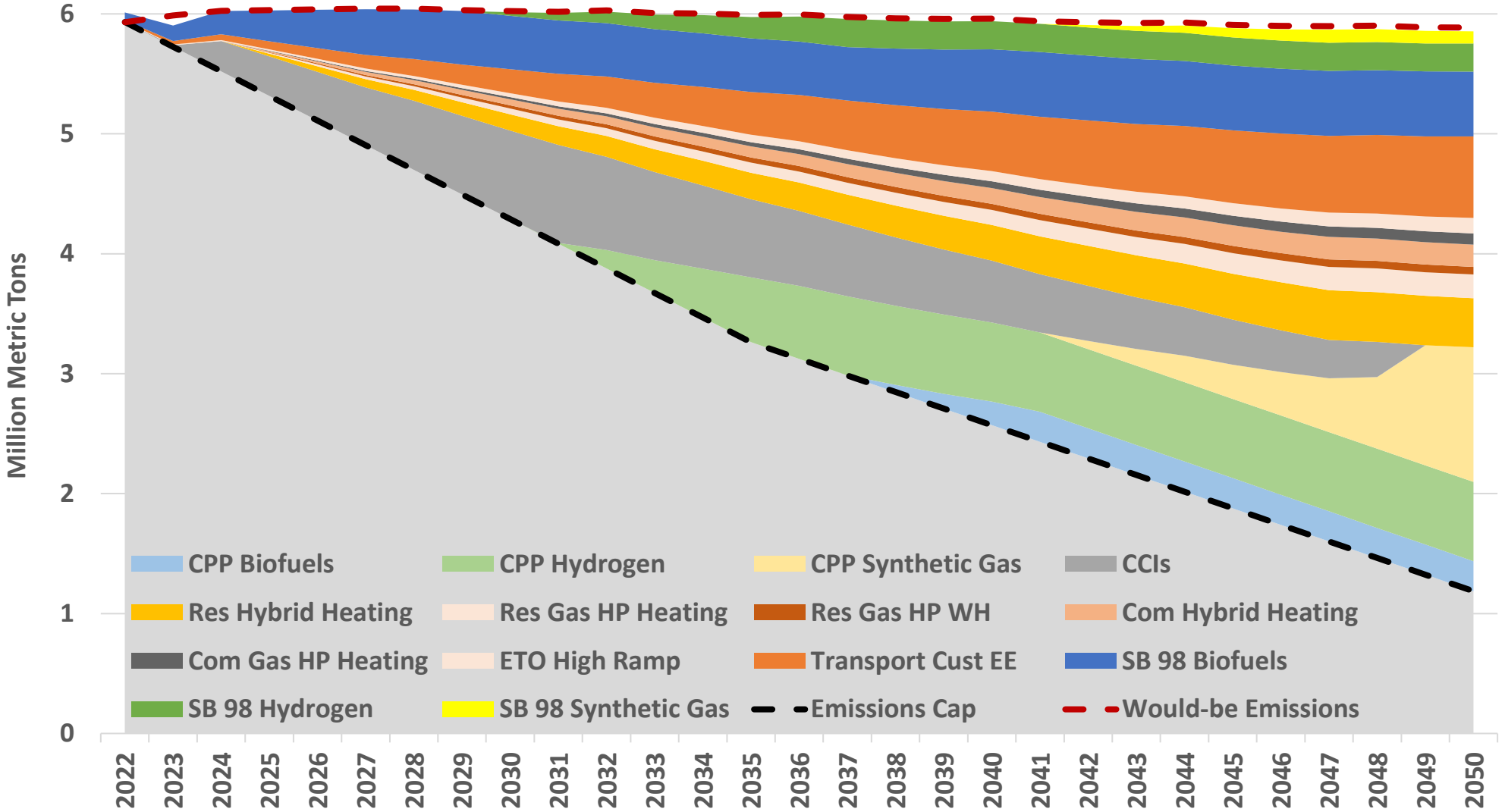
- Shows total renewable portfolio, including both SB 98 and CPP needs
- Biofuels RNG reach ~13% of current deliveries by 2050
- Total renewable portfolio represents ~8% of current deliveries in 2030 and ~50% of current deliveries in 2050 (representing 72% of 2050 deliveries)
- Blended green hydrogen represents 20% of deliveries in later years, with hydrogen derived synthetic green methane filling in the portfolio in the 2040's

Draft Renewable Supply Acquisition

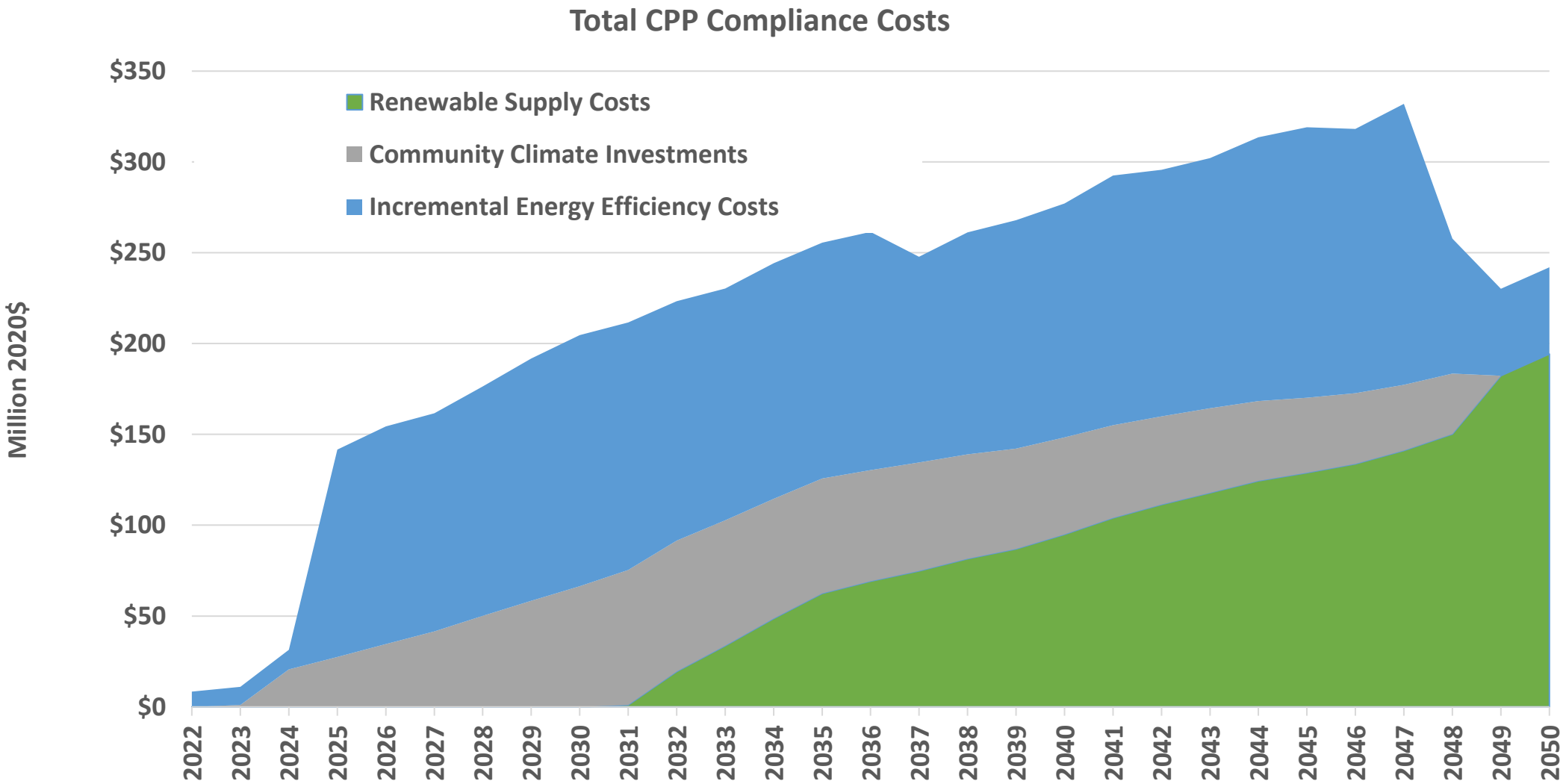


- Maximum biofuel penetration in any year is 14% of current deliveries and represents roughly half of Oregon's population weighted share of the national biofuel RNG resource
- Renewables reach 72% of deliveries in 2050

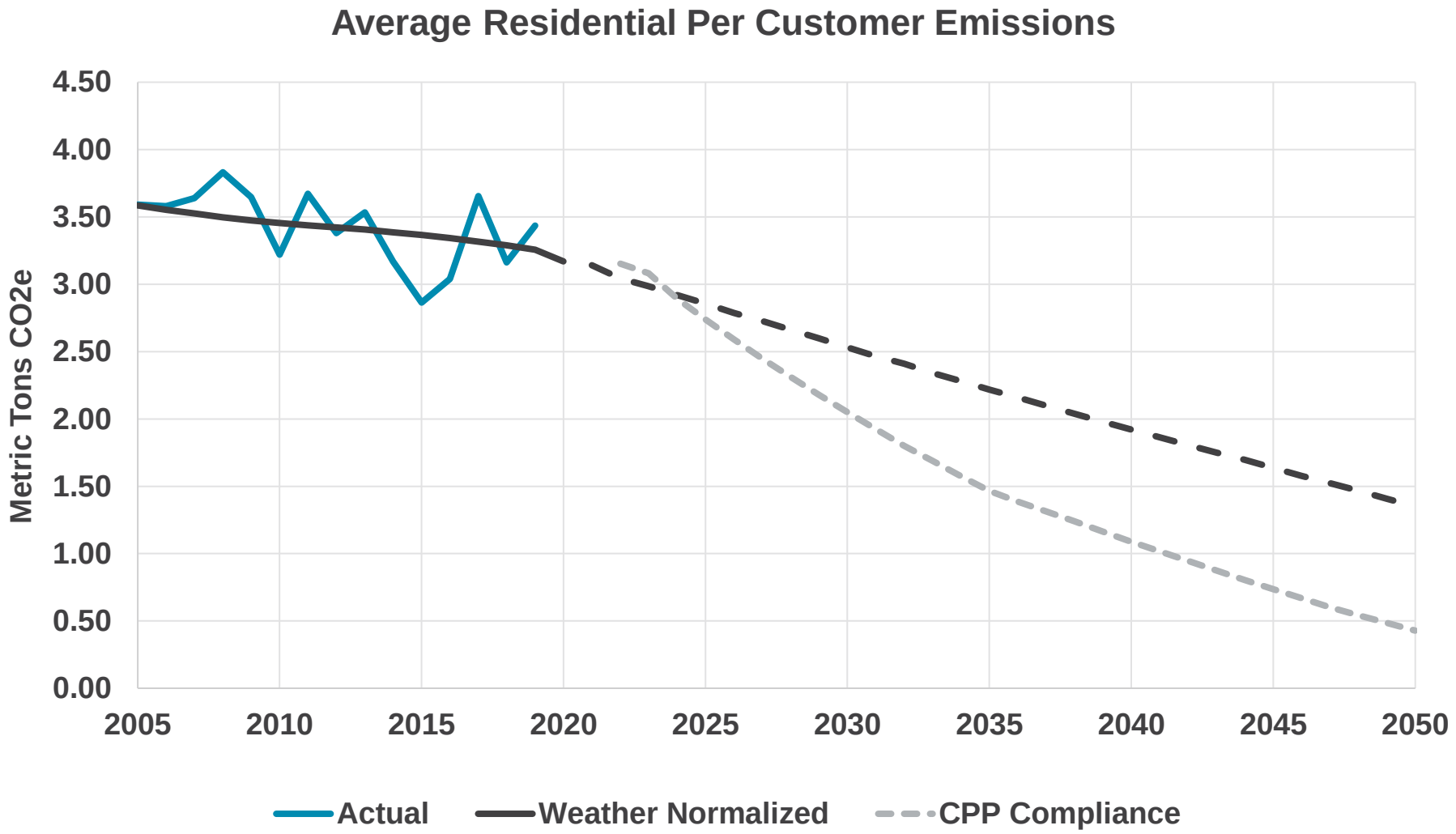
Draft Base Case CPP Compliance Strategy



Draft CPP Compliance Costs

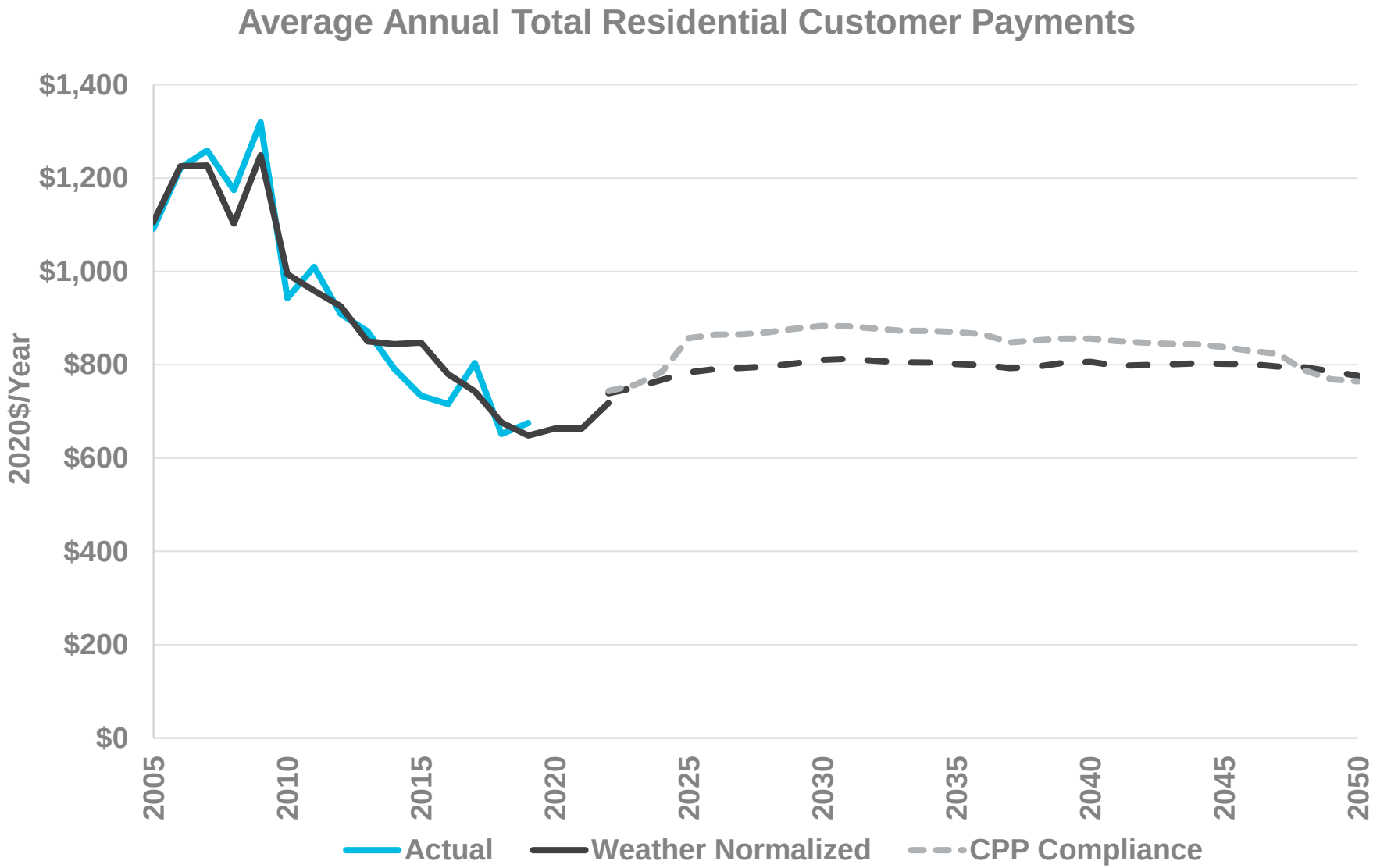


Draft Residential Emissions Under CPP Compliance



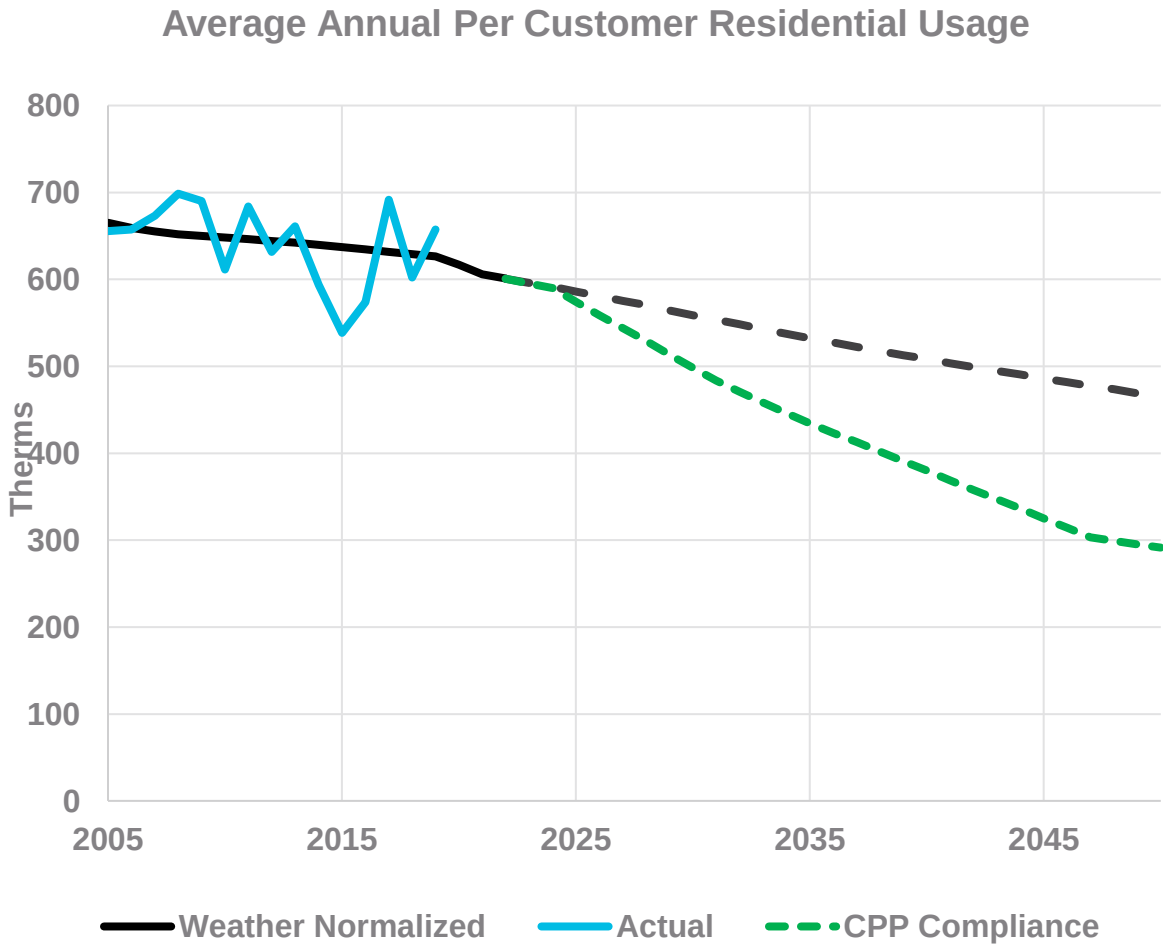
Total NW Natural Residential Emissions in 2050 represent less than 0.5 Million Metric Tons of CO2e (<1% of Oregon's current emissions)

Impact on Residential Total Gas Utility Payments



- Total utility bills depend upon usage and utility rates
- Total bill = Usage x Total All-in Rate

Constructing Impact on Customer Bills: Combined Impact of Usage and Utility Rates



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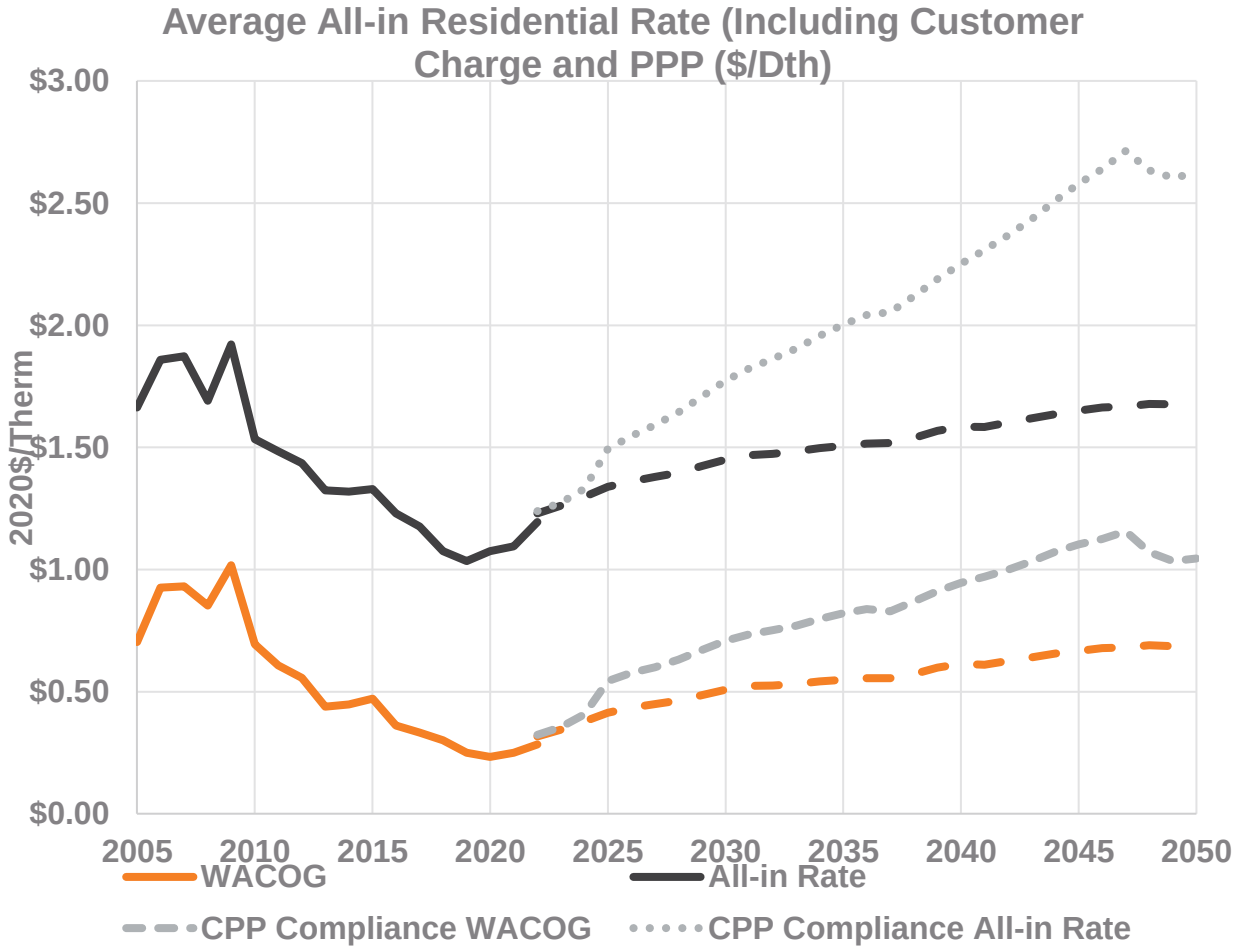
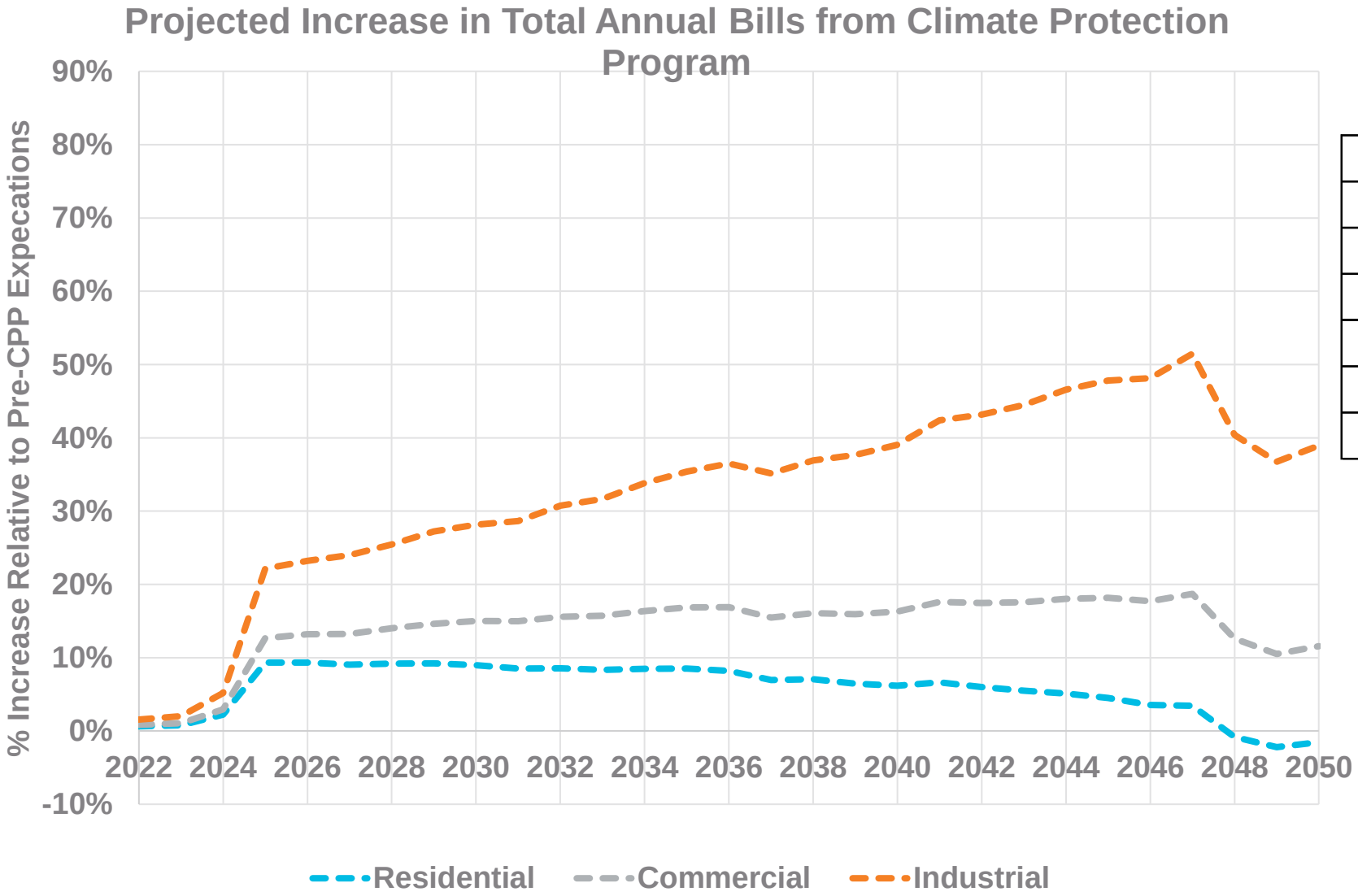


Impact of CPP to Customer Annual Gas Bills



	Residential	Commercial	Industrial
2022	1%	1%	2%
2025	9%	13%	22%
2030	9%	15%	28%
2035	9%	17%	35%
2040	6%	16%	39%
2050	-2%	12%	39%

***Impact shown relative to pre-CPP expectations, including SB 98 and expected energy efficiency action**

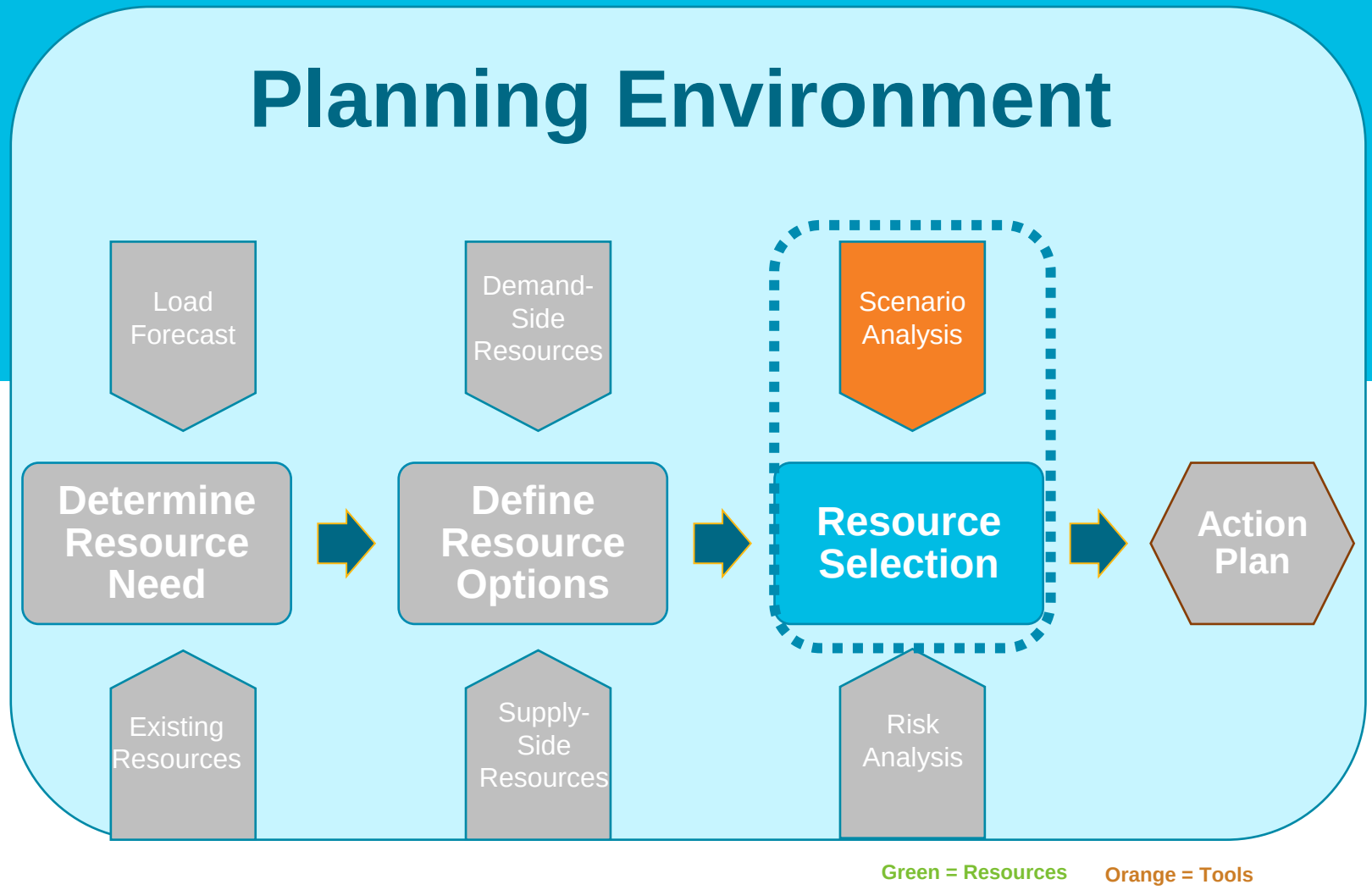
Alternative Scenarios Analyzed

OPUC Staff Directed Scenarios:

- **Restricted RNG Supply**
- **Customer Decline**
- **More Aggressive Compliance Targets**
- **No Community Compliance Investments**

Additional Scenarios Considered:

- **Federal Renewable Gaseous Fuel Support**
- **Community-minded Voluntary Programs**



Key Scenario Assumptions

NW Natural®

OPUC Staff Directed Scenarios:

- **Restricted RNG Supply**
  - Biofuel RNG restricted to half of SB 98 targets and RNG portfolio tranche 2 cost is applied to all biofuel RNG. Hydrogen and Synthetic gas costs use Syngas cost assumptions
- **Customer Decline**
  - Current IRP forecasted load growth through 2025; no new customers beginning from 2025 through 2030; -0.75% customer growth beginning in 2031 through the end of model's time horizon.
- **More Aggressive Compliance Targets**
  - CPP targets of 45% below baseline by 2030, 80% below baseline by 2040
- **No Community Compliance Investments**

Additional Scenarios Considered:

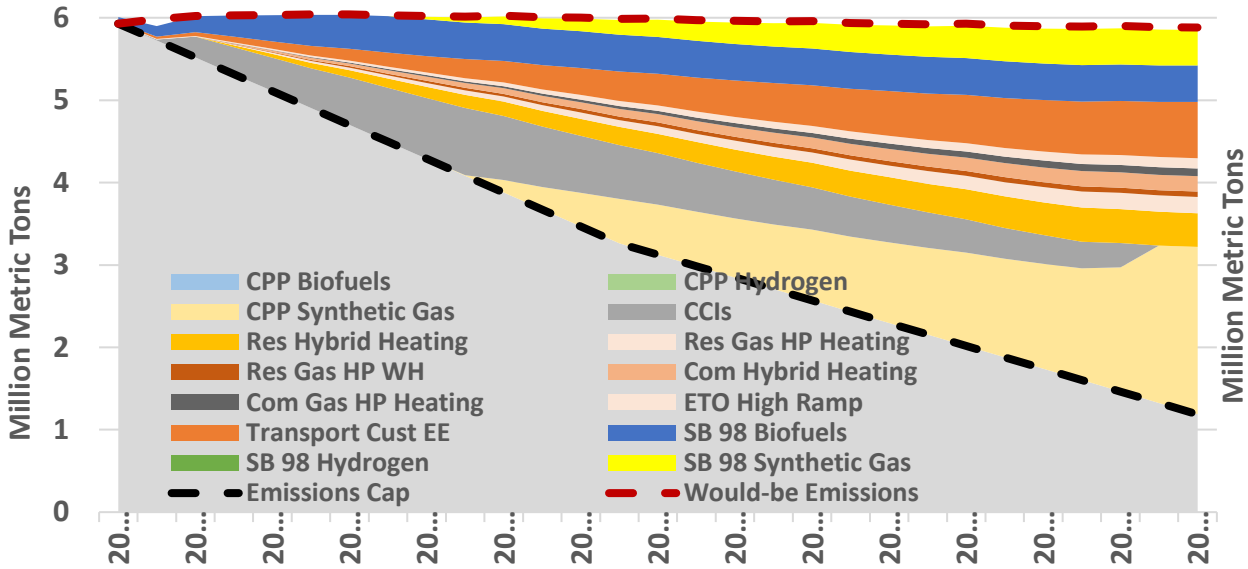
- **Federal Renewable Gaseous Fuel Support**
  - Renewable energy production tax credit of 30% extended to hydrogen and synthetic gas infrastructure and to biofuel RNG
- **Community-minded Voluntary Programs**
  - Smart Energy program counts for compliance

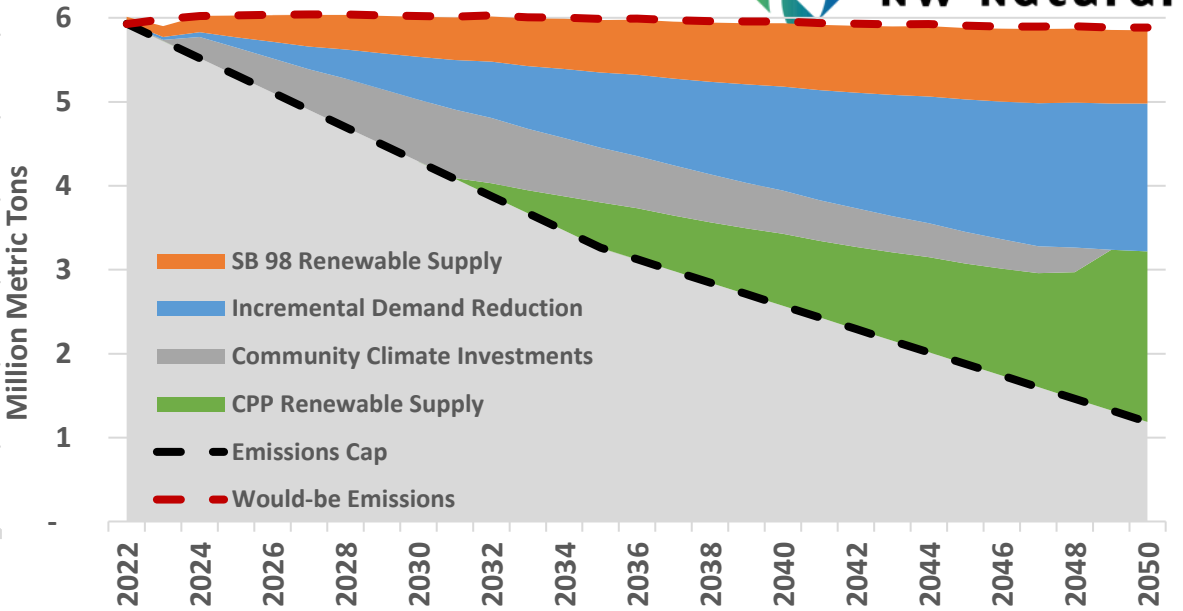
Scenario Comparison- Key Results

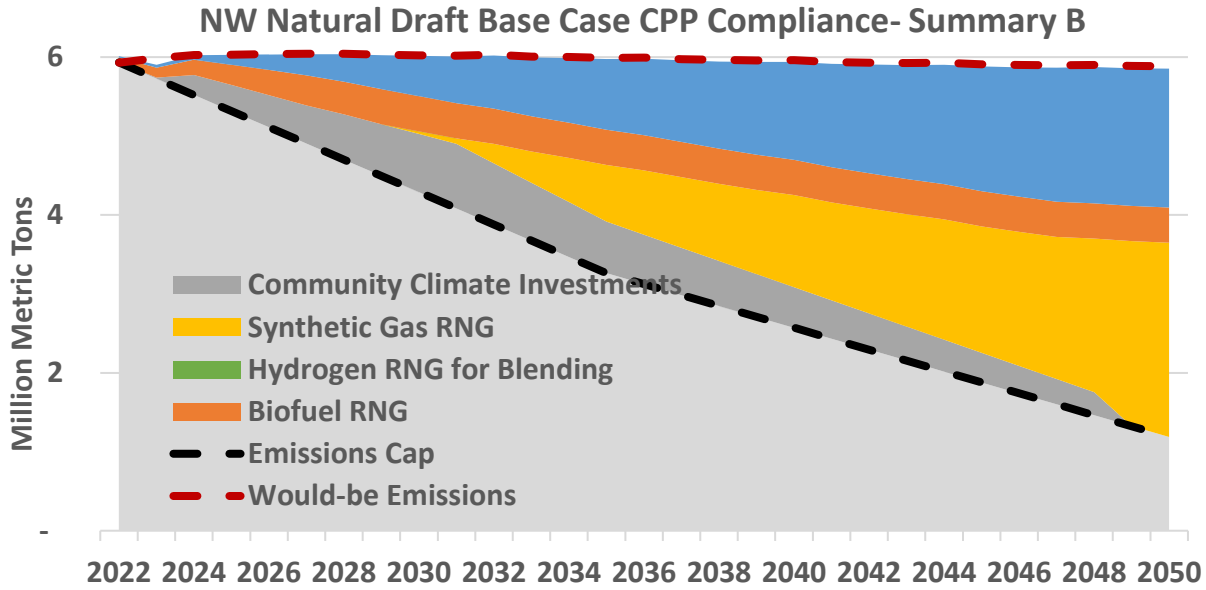
Scenario	Renewable Supply Penetration (% of Deliveries)			Biofuel RNG Penetration (% of Current Deliveries)			Renewable Supply Portfolio Cost (2020$/Dth)			Total Incremental Cost of CPP Program (Million 2020$/Year)			Community Climate Investments (% of Emissions)			Annual Residential Bill Impact (% Impact of CPP)			Annual Industrial Sales Bill Impact (% Impact of CPP)		
	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050
Base Case	*4%*	*23%*	*72%*	*4%*	*8%*	*14%*	*$12.25*	*$11.85*	*$11.77*	*$142*	*$256*	*$242*	*6%*	*20%*	*0%*	*9%*	*9%*	*-2%*	*22%*	*35%*	*39%*
Restricted RNG	4%	23%	72%	4%	9%	11%	$18.75	$18.26	$16.90	$142	$317	$324	6%	20%	0%	13%	19%	9%	30%	59%	68%
Customer Decline	4%	17%	65%	4%	9%	15%	$12.25	$11.93	$11.59	$118	$181	$186	6%	20%	0%	8%	15%	18%	18%	27%	37%
Aggressive Timeline	4%	47%	65%	4%	16%	20%	$12.25	$13.15	$11.74	$168	$493	$360	13%	20%	20%	10%	23%	2%	27%	73%	58%
No CCIs	10%	36%	72%	10%	15%	18%	$12.25	$12.64	$12.89	$167	$313	$296	0%	0%	0%	11%	13%	3%	26%	45%	51%
Federal RNG Support	4%	23%	72%	4%	8%	14%	$8.58	$8.76	$8.80	$142	$239	$160	6%	20%	0%	7%	4%	-9%	18%	26%	17%
Voluntary Community Support	4%	16%	48%	4%	8%	9%	$12.25	$11.85	$11.25	$124	$214	$160	2%	20%	20%	8%	6%	-6%	19%	30%	25%

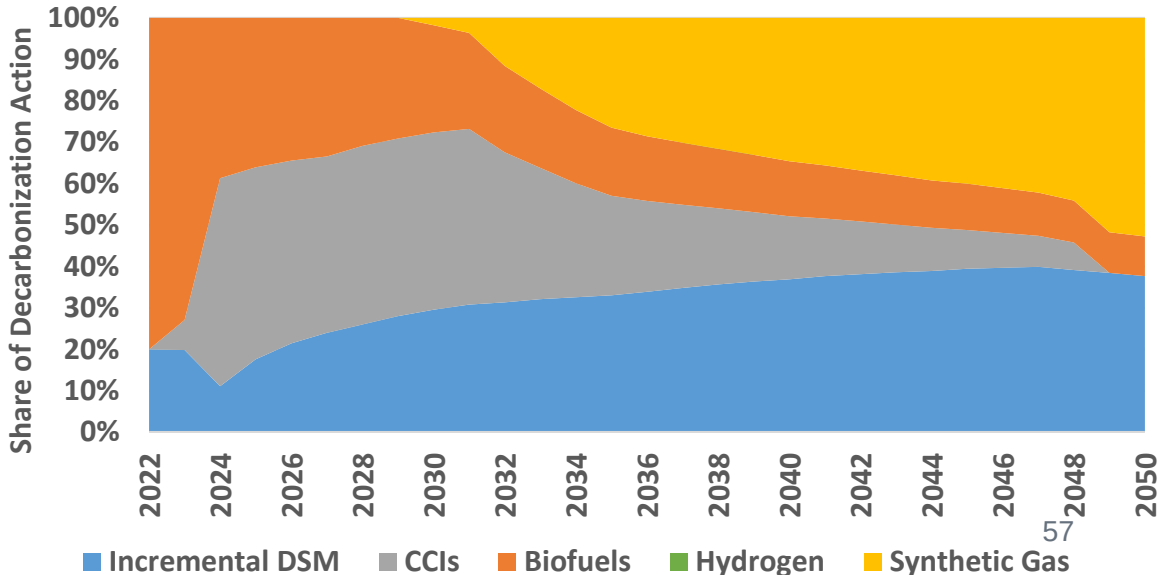
Appendix

Restricted RNG Scenario- Key Results

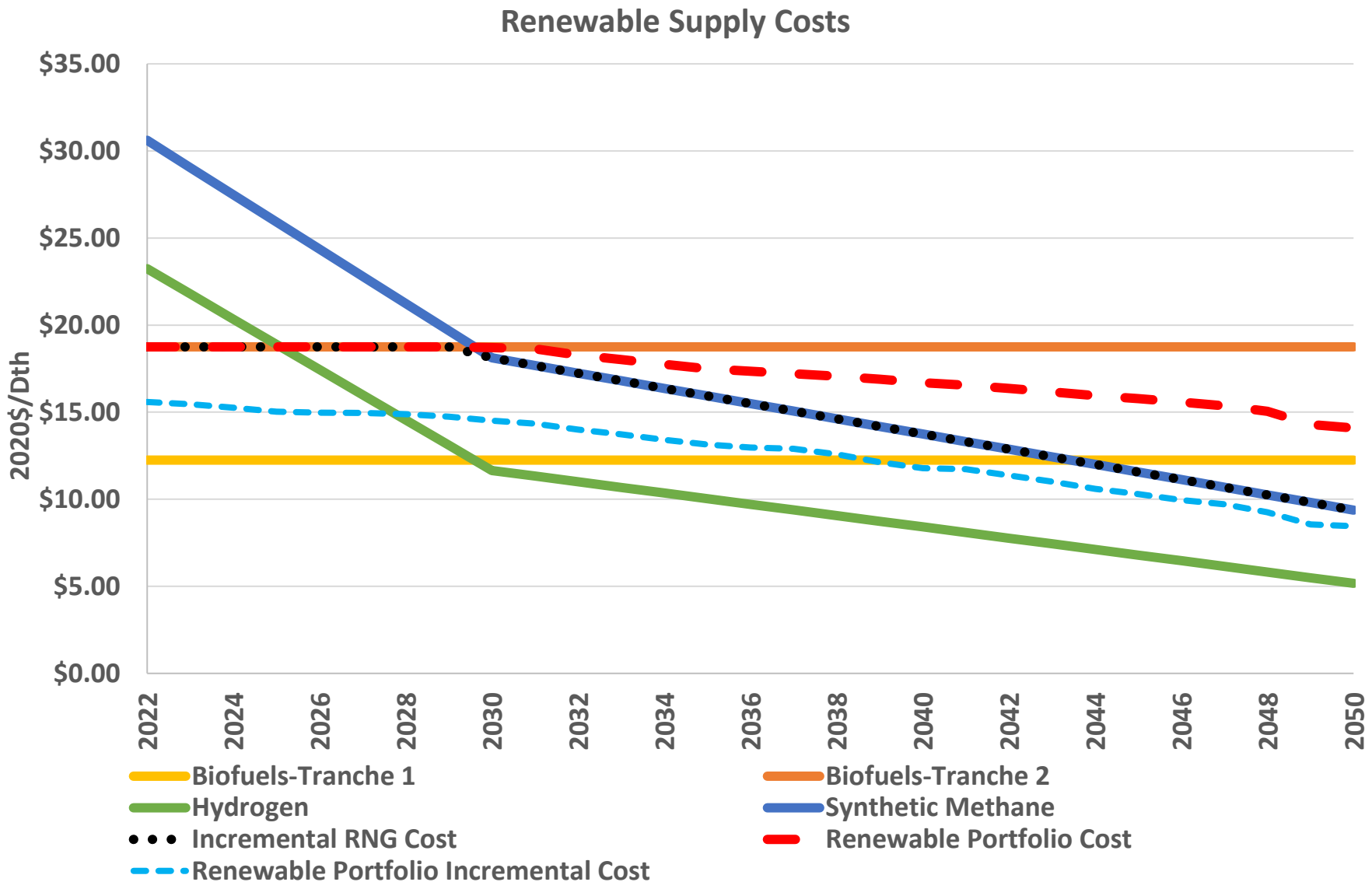




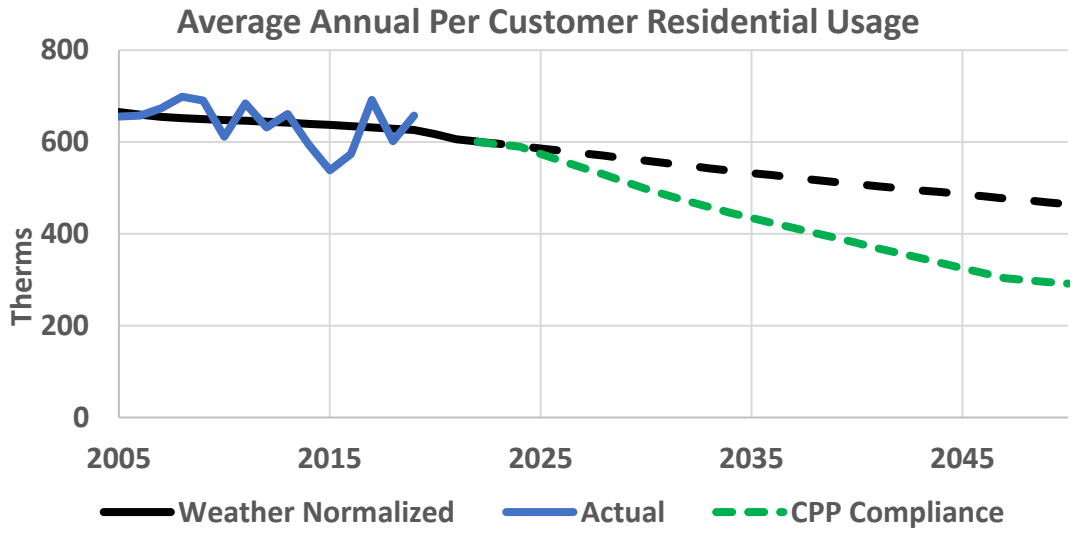


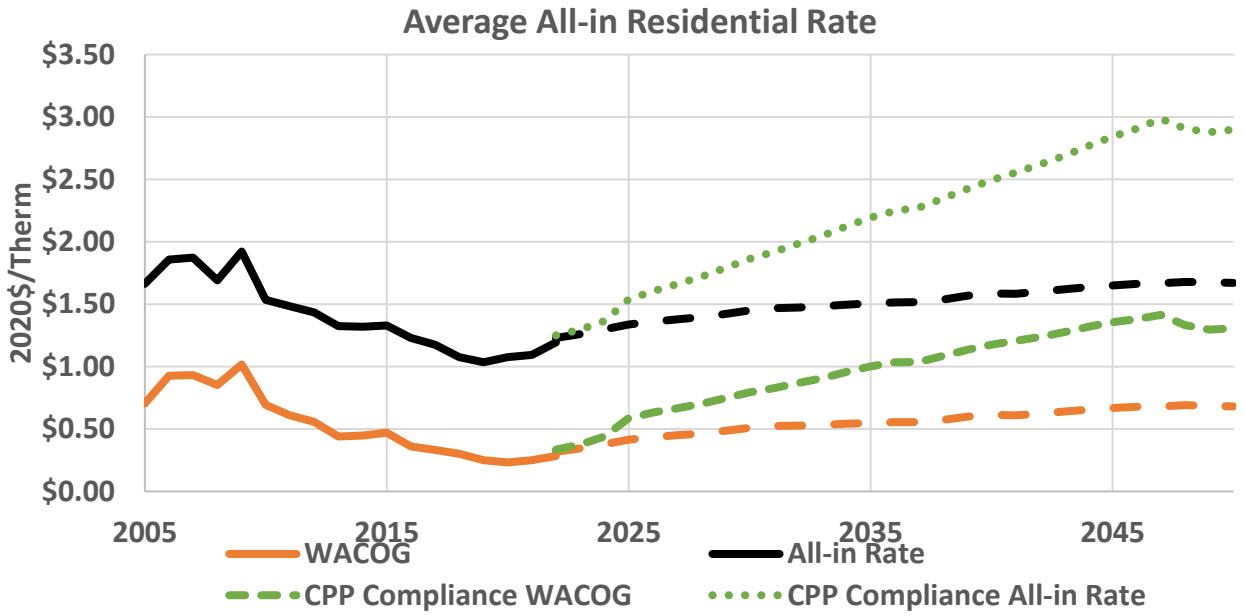


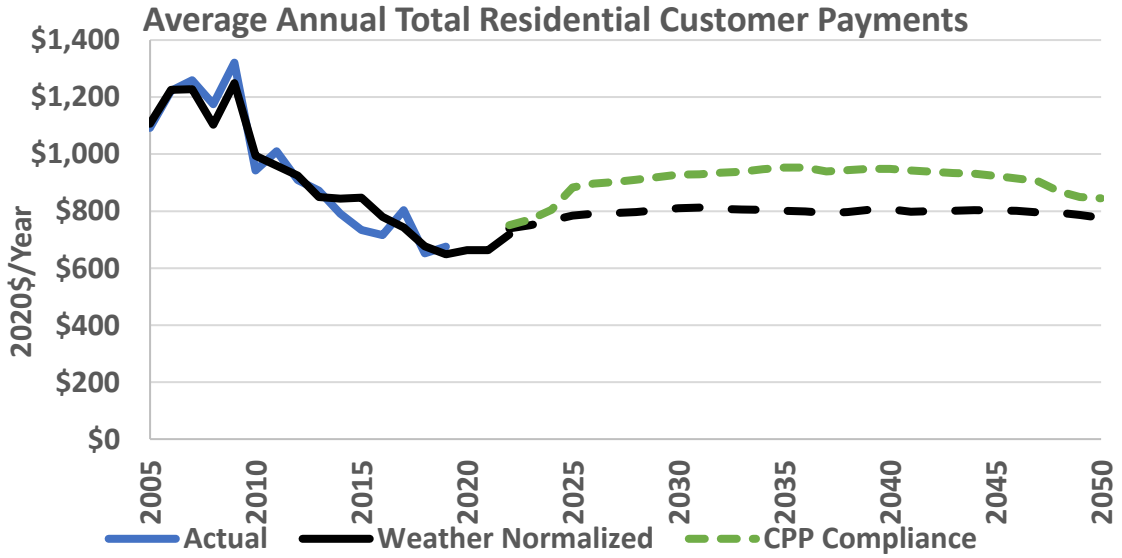
Restricted RNG Scenario- Renewable Supply Results

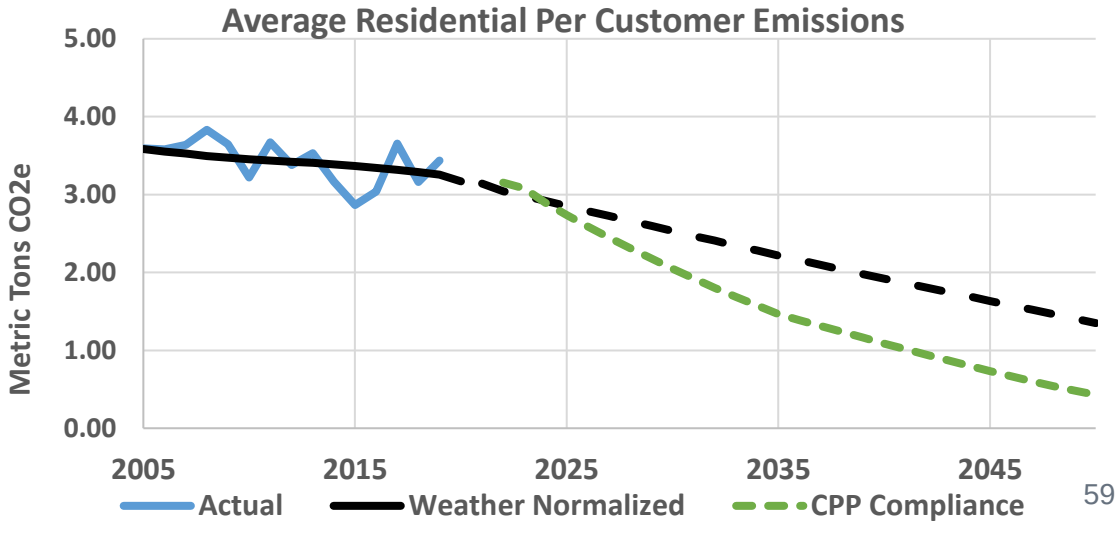


Restricted RNG Scenario- Residential Results

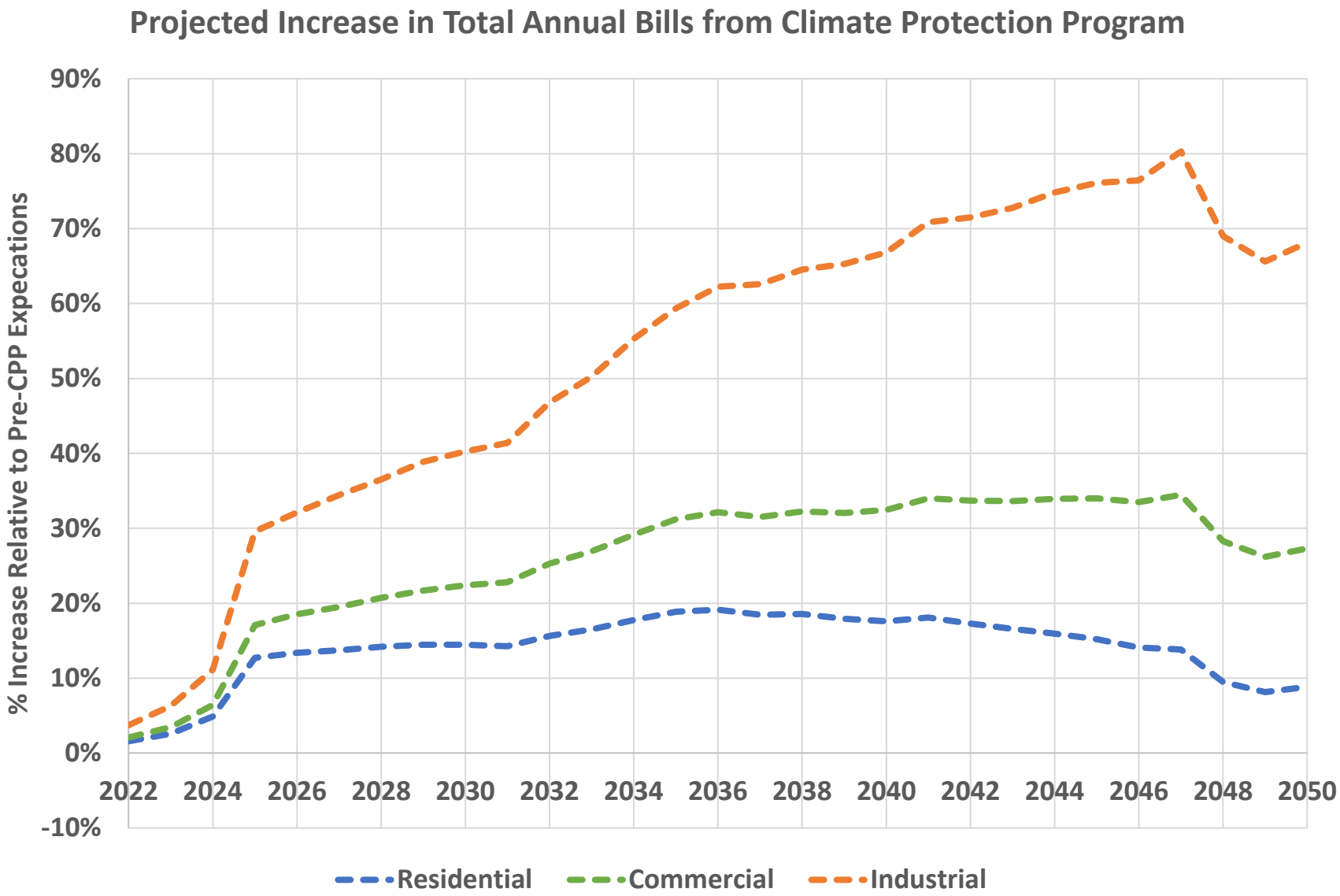






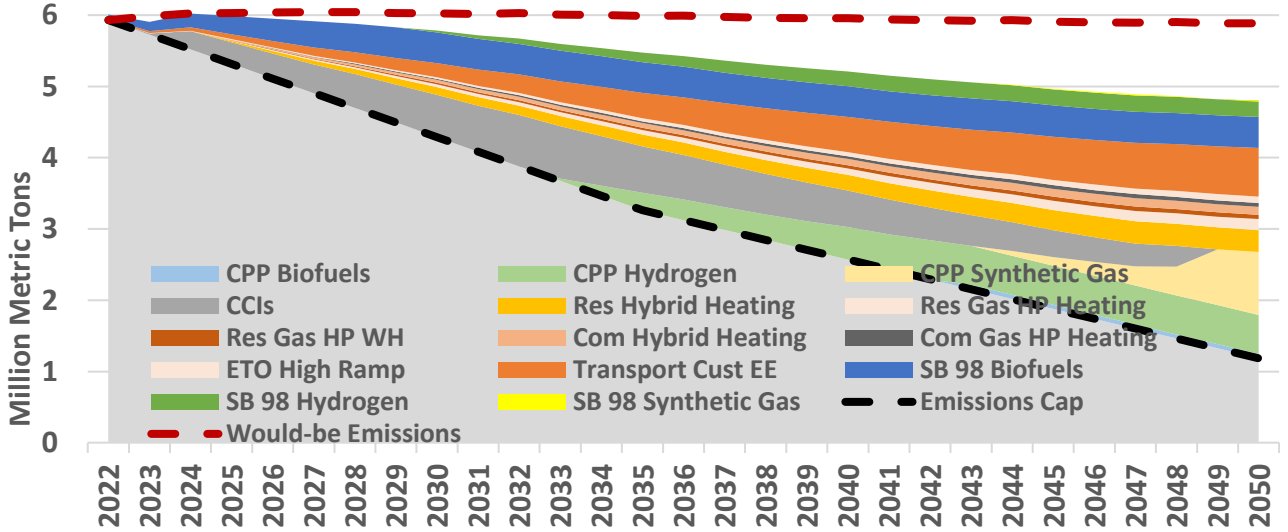


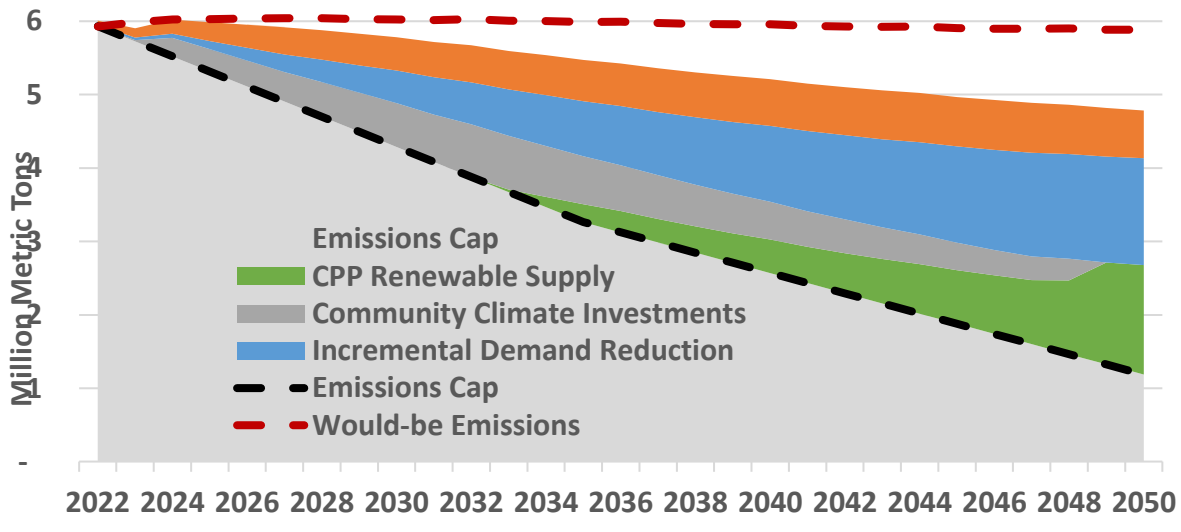
Restricted RNG Scenario- Bill Impacts

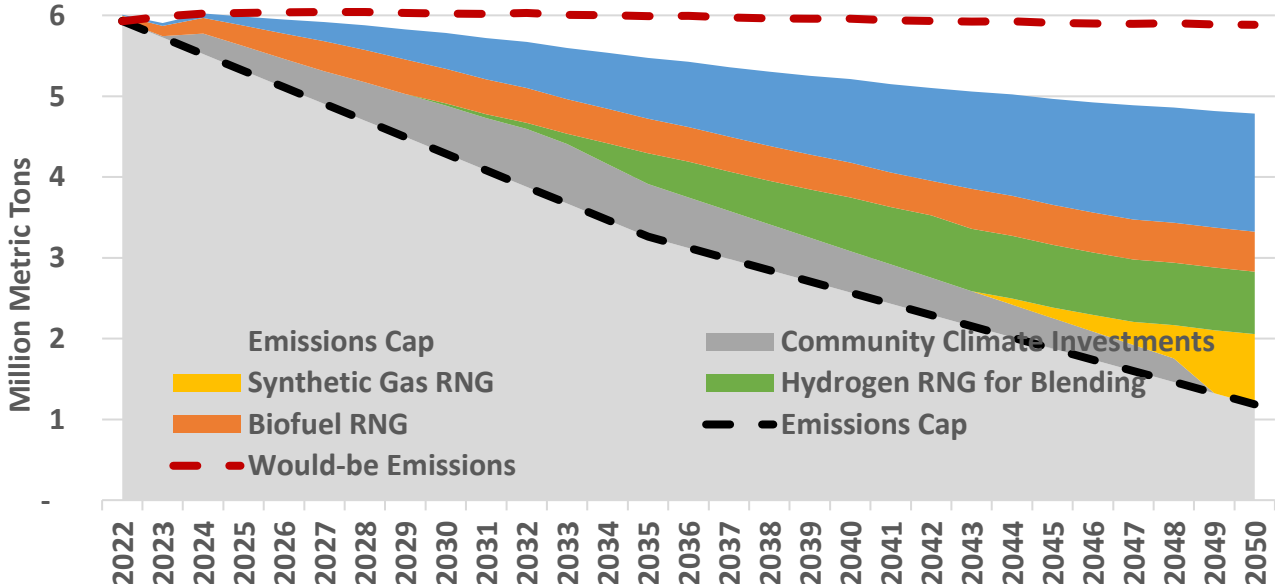


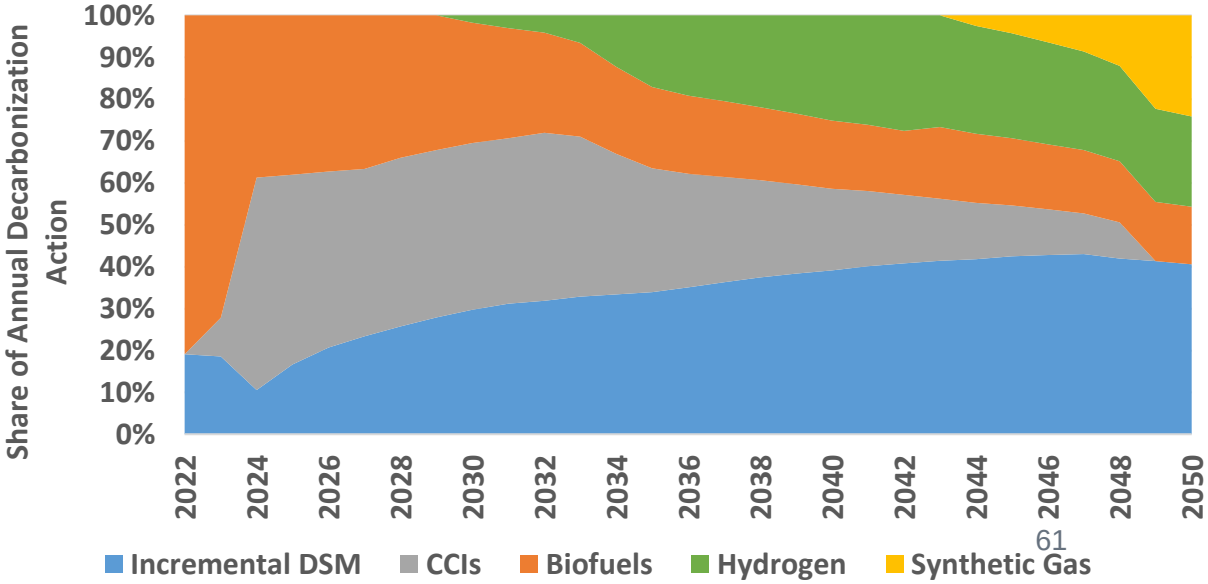
	Residential	Commercial	Industrial
2022	2%	2%	4%
2025	13%	17%	30%
2030	14%	22%	40%
2035	19%	31%	59%
2040	18%	32%	67%
2050	9%	27%	68%

Customer Decline Scenario- Key Results

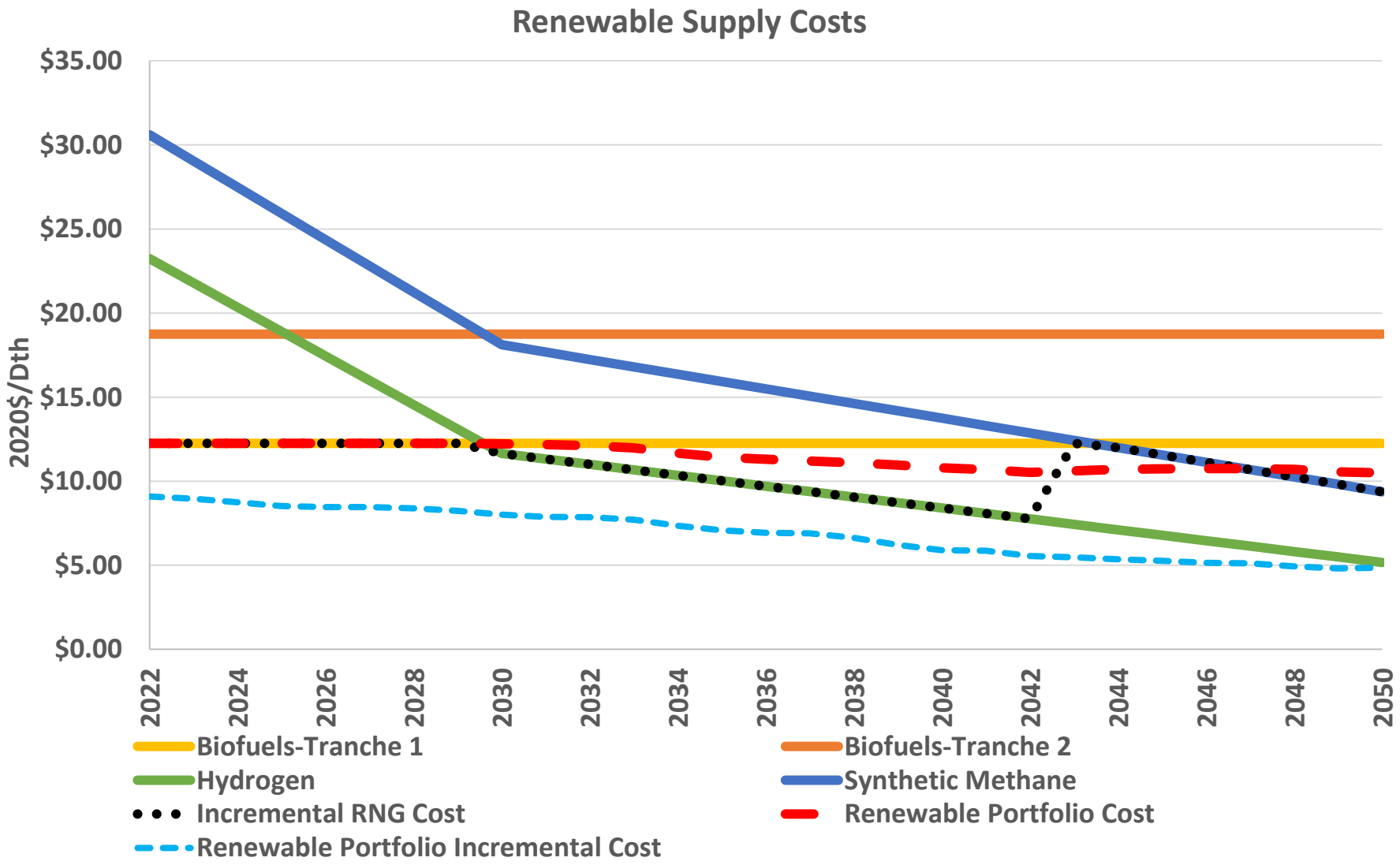




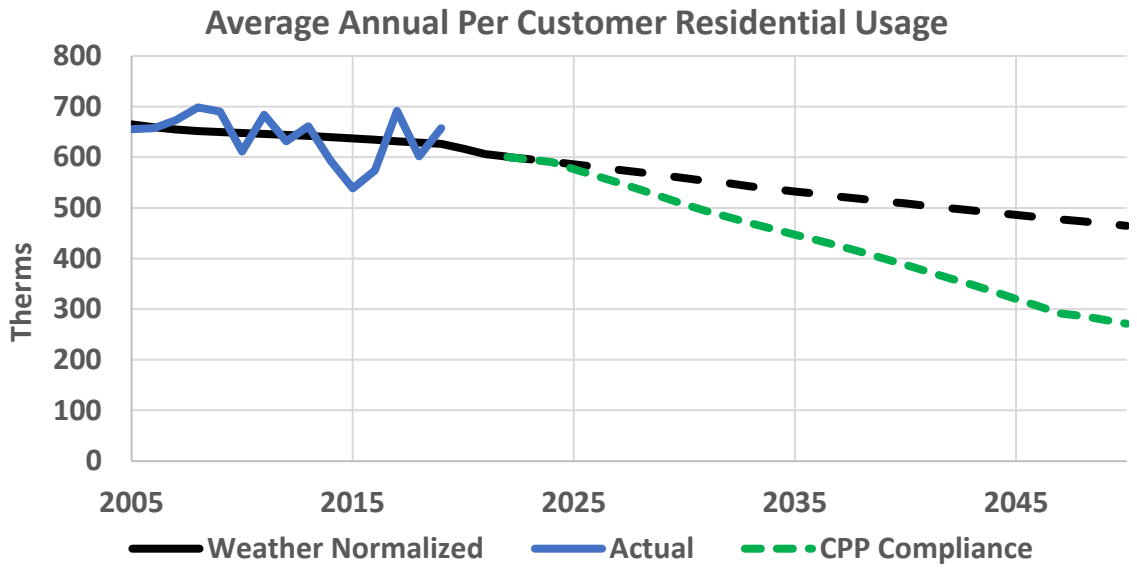


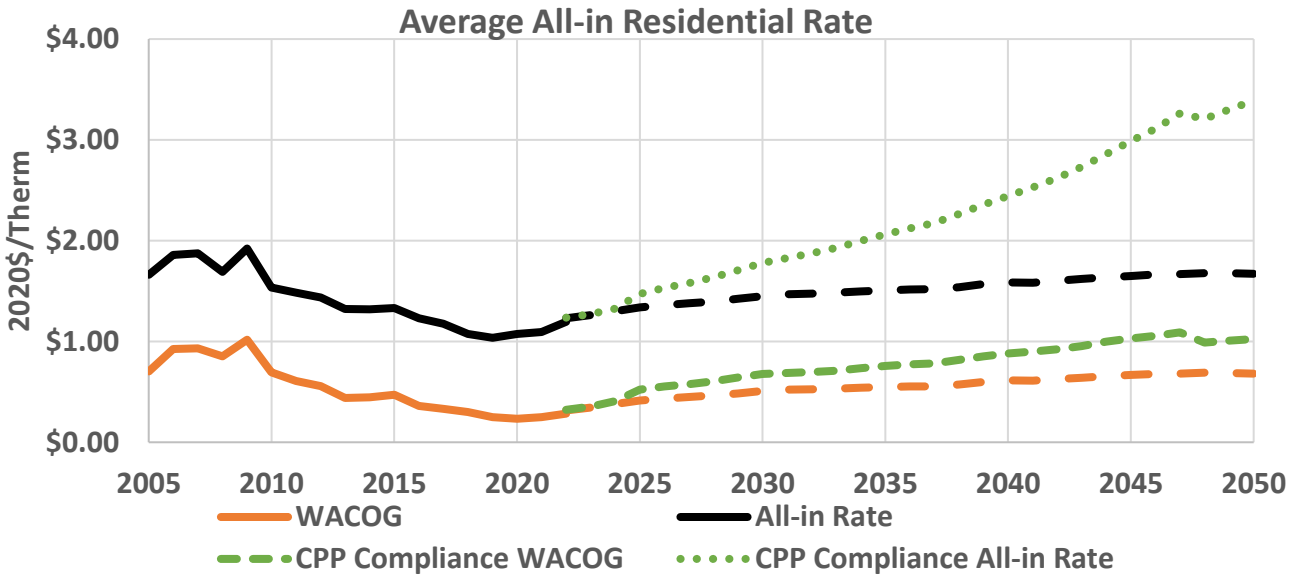


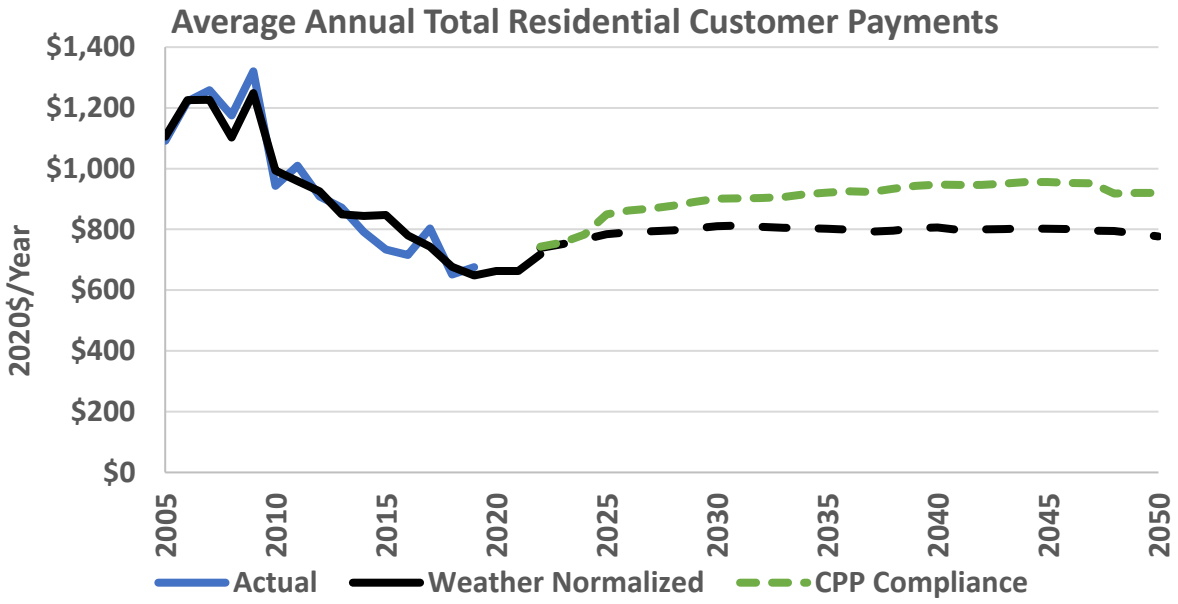
Customer Decline Scenario- Renewable Supply Results

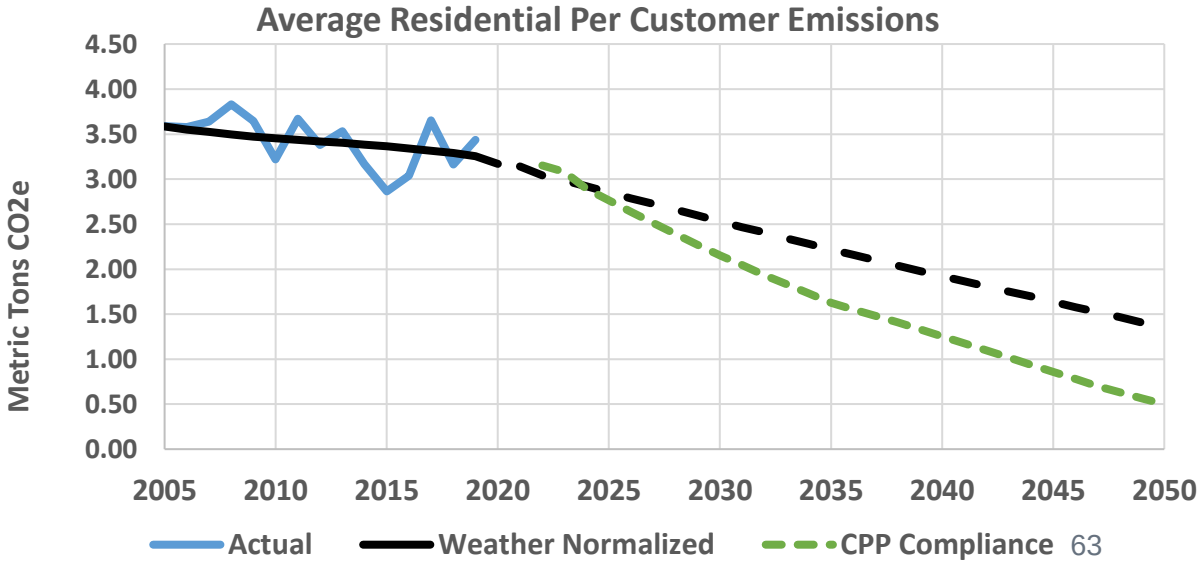


Customer Decline Scenario- Residential Results

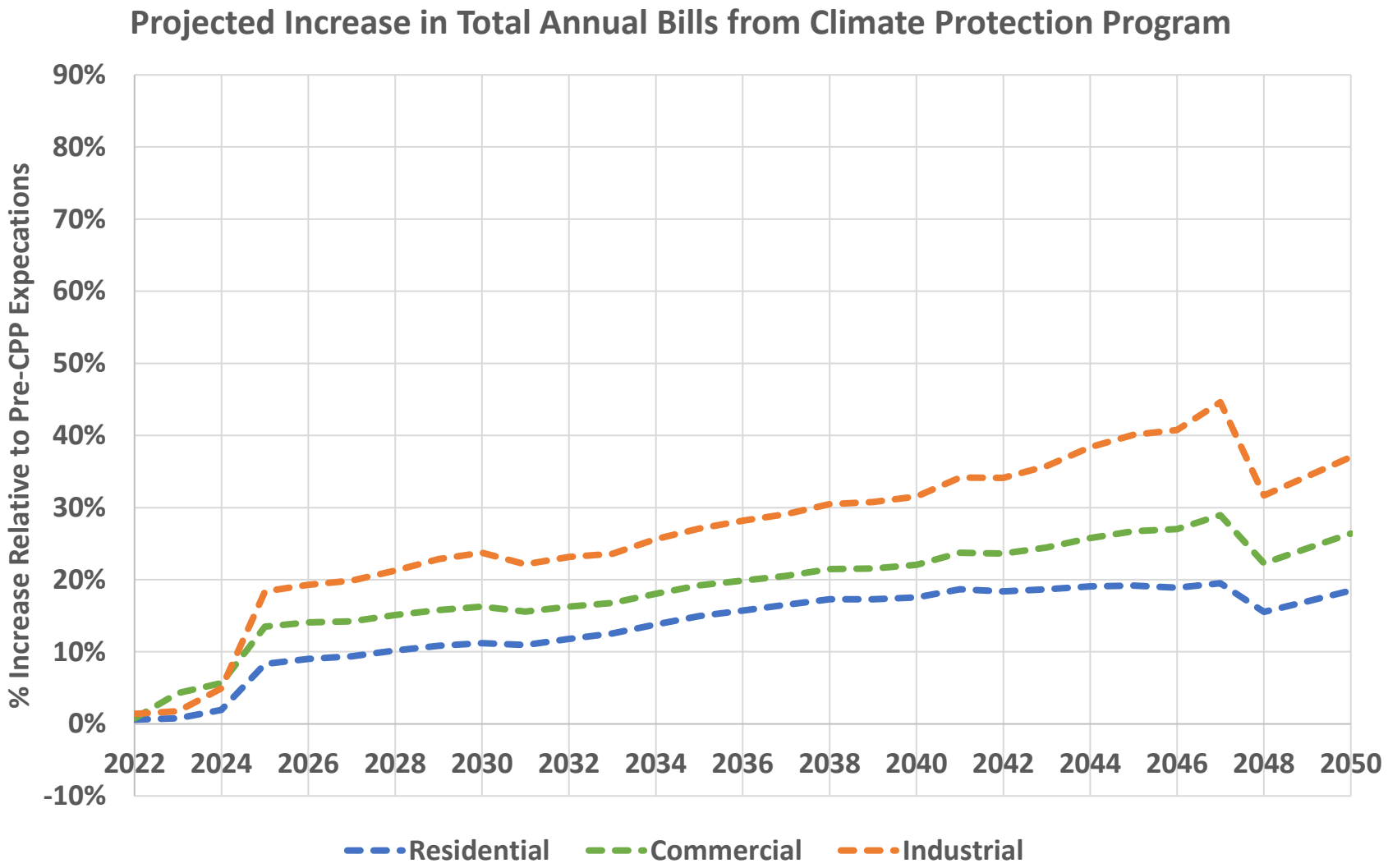






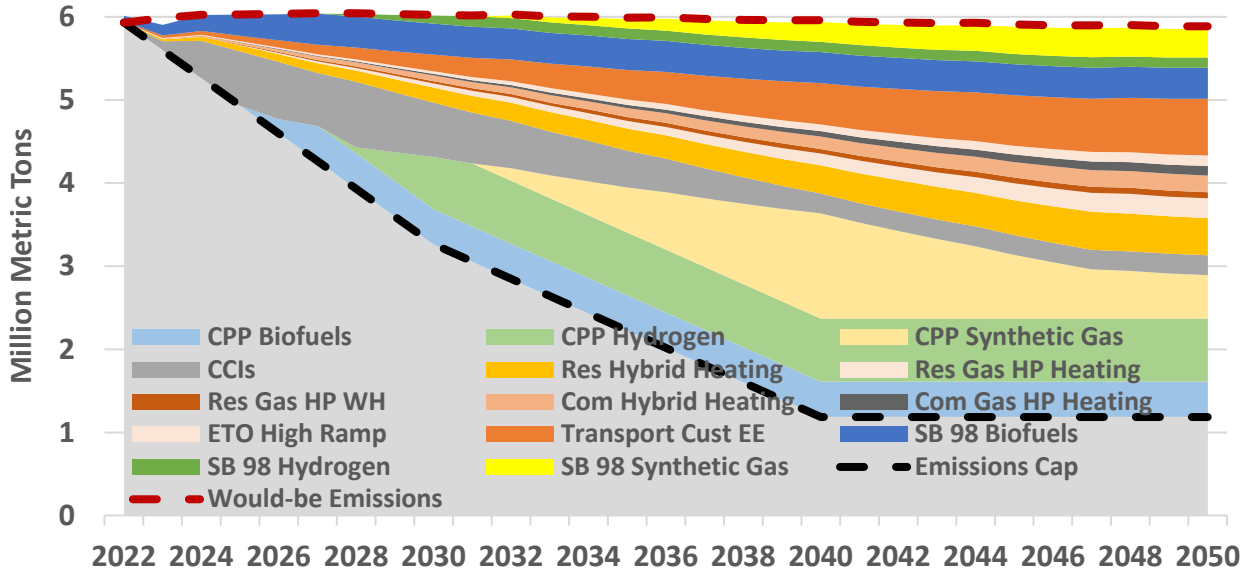


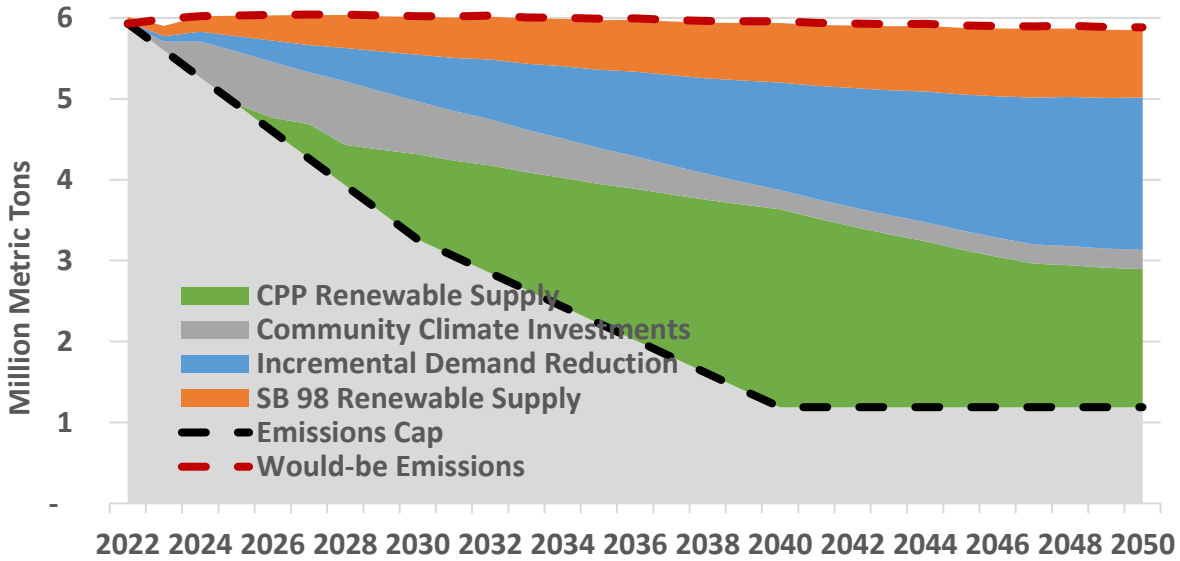
Customer Decline Scenario- Bill Impacts

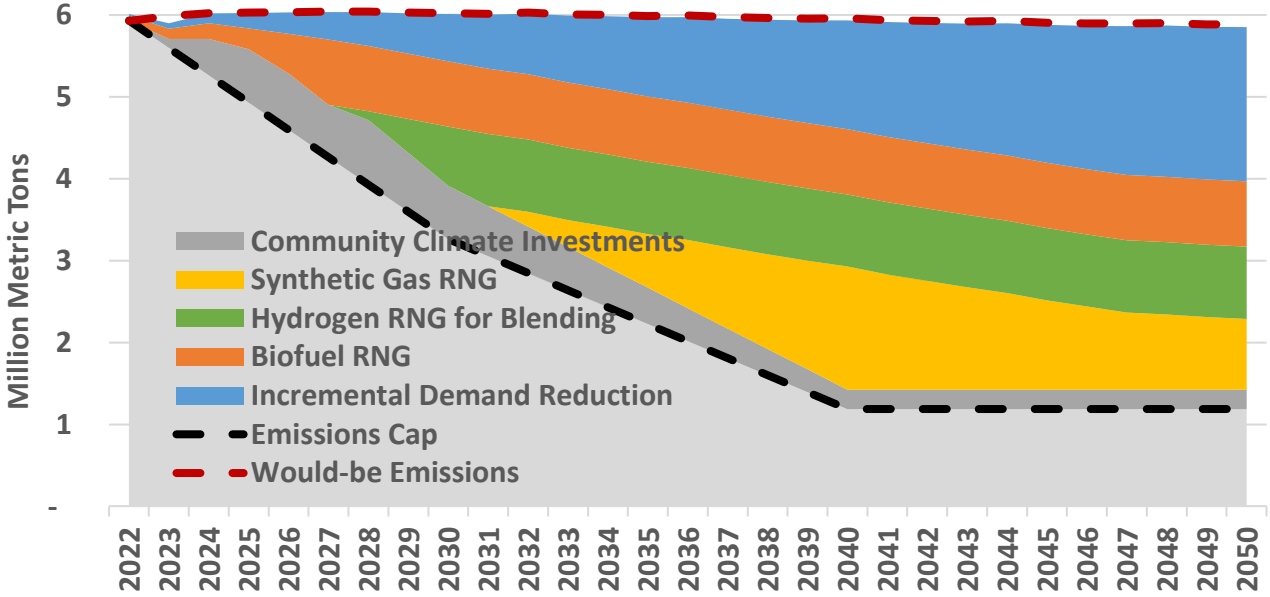


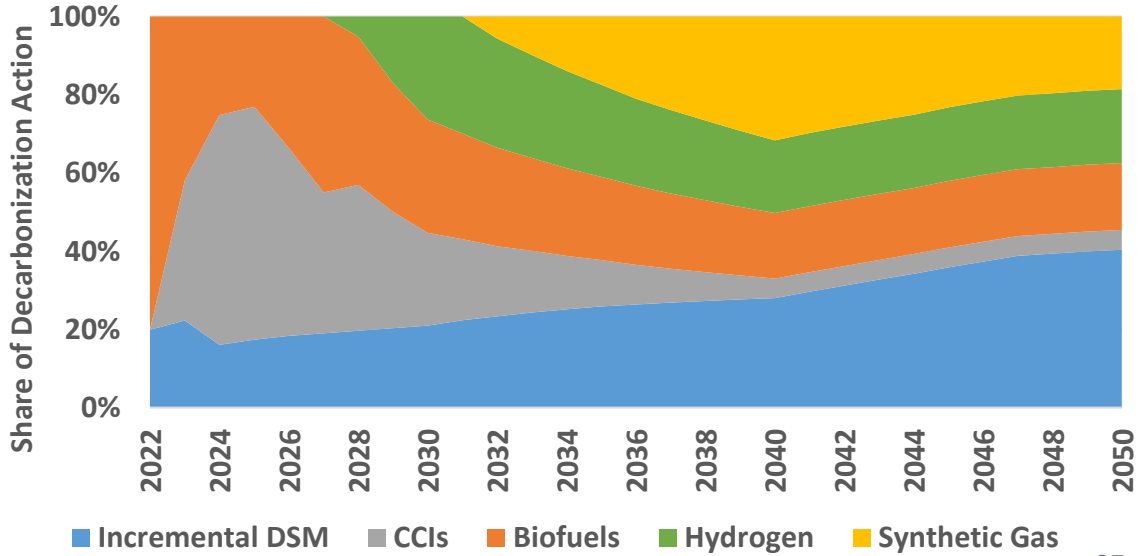
	Residential	Commercial	Industrial
2022	1%	1%	1%
2025	8%	14%	18%
2030	11%	16%	24%
2035	15%	19%	27%
2040	18%	22%	32%
2050	18%	26%	37%

Aggressive Timeline Scenario- Key Results

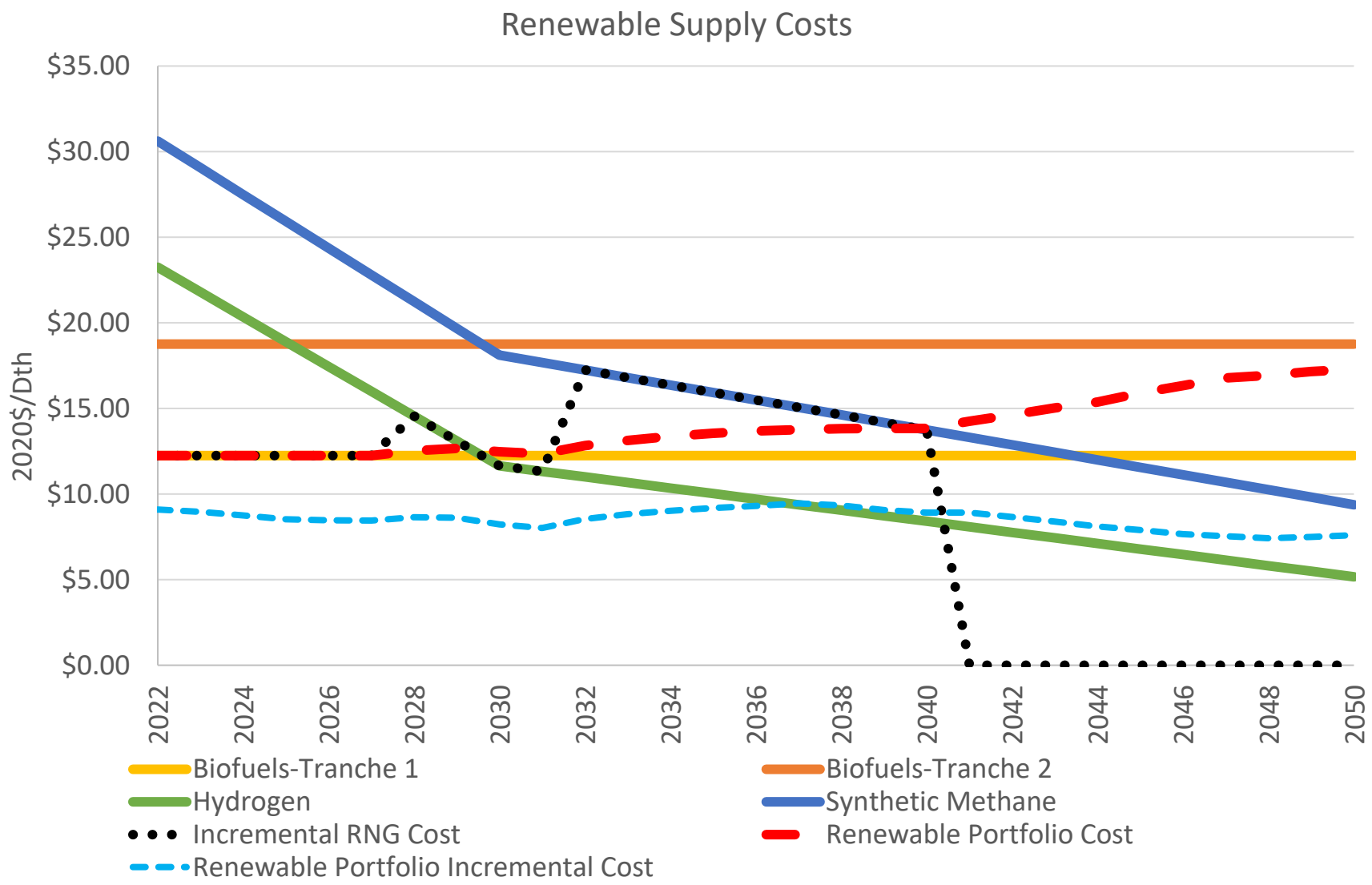




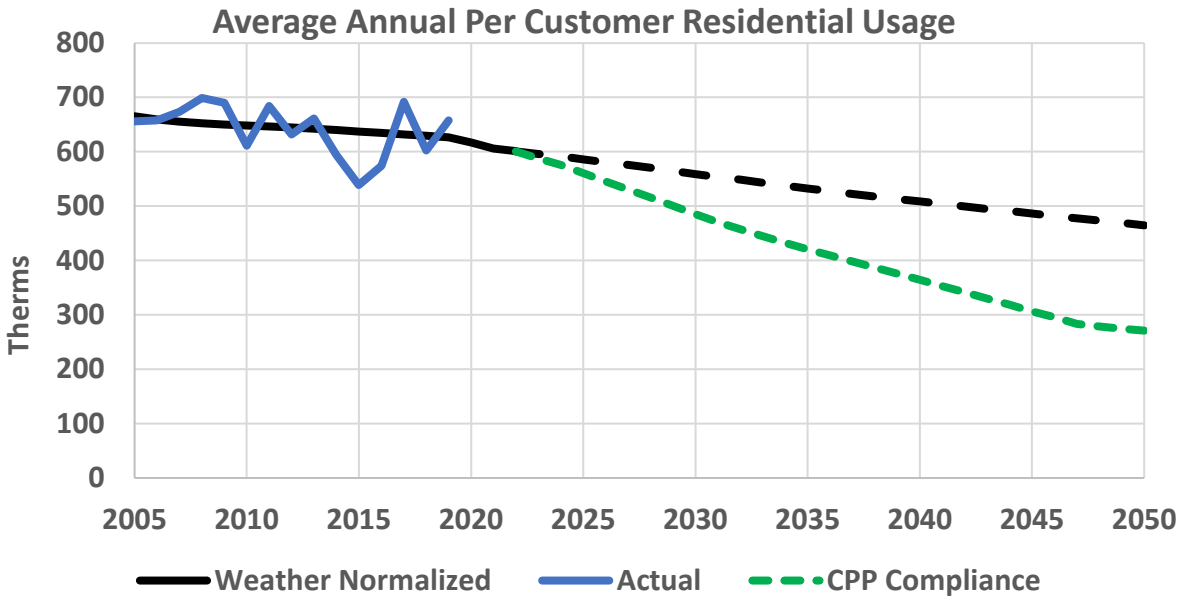


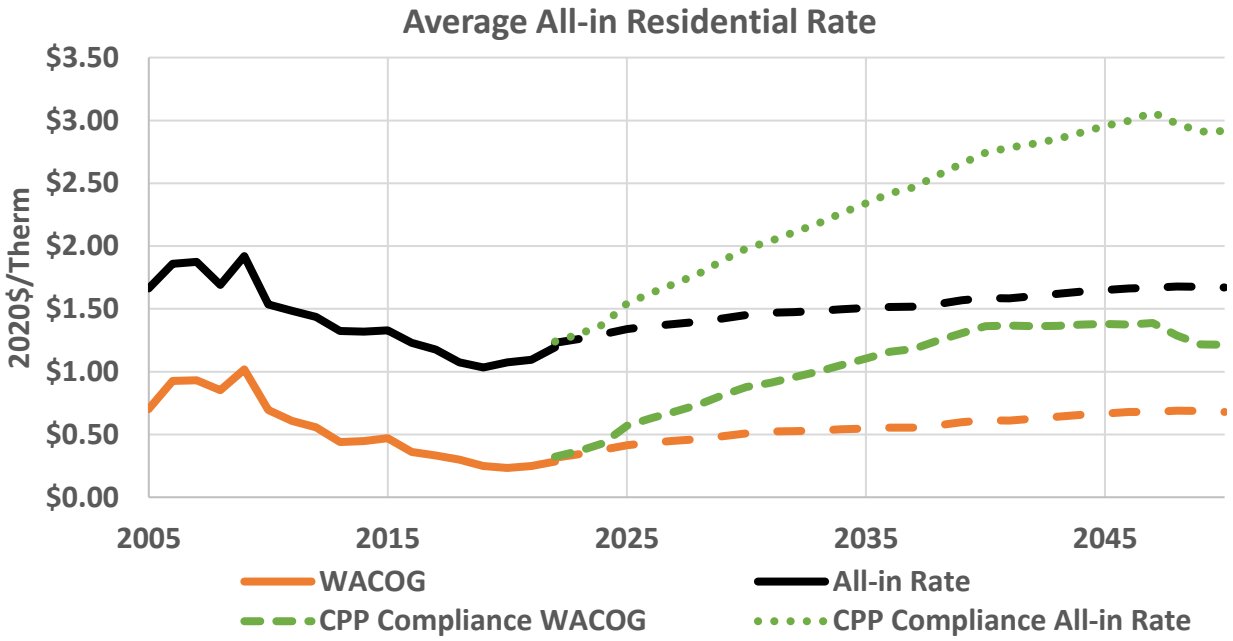


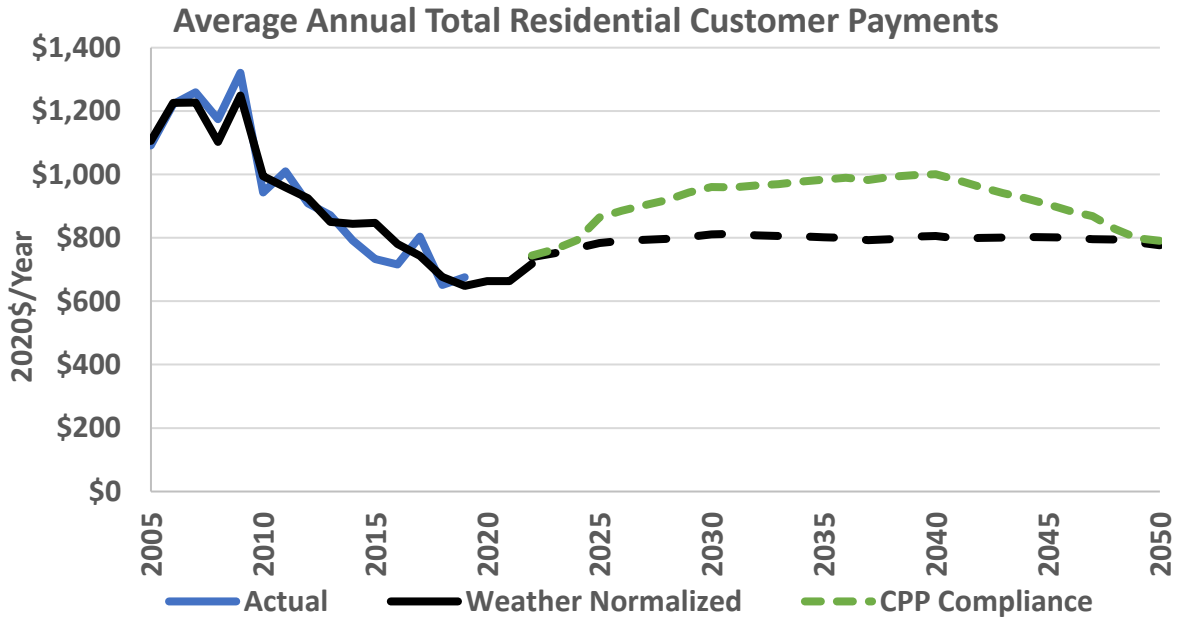
Aggressive Timeline Scenario- Renewable Supply Results

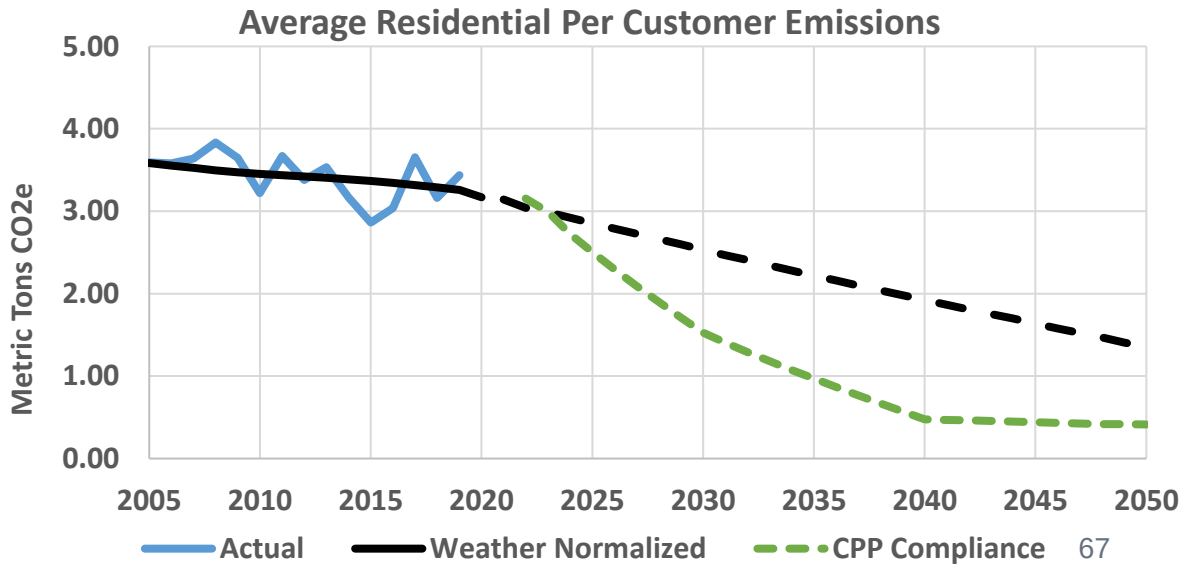


Aggressive Timeline Scenario- Residential Results

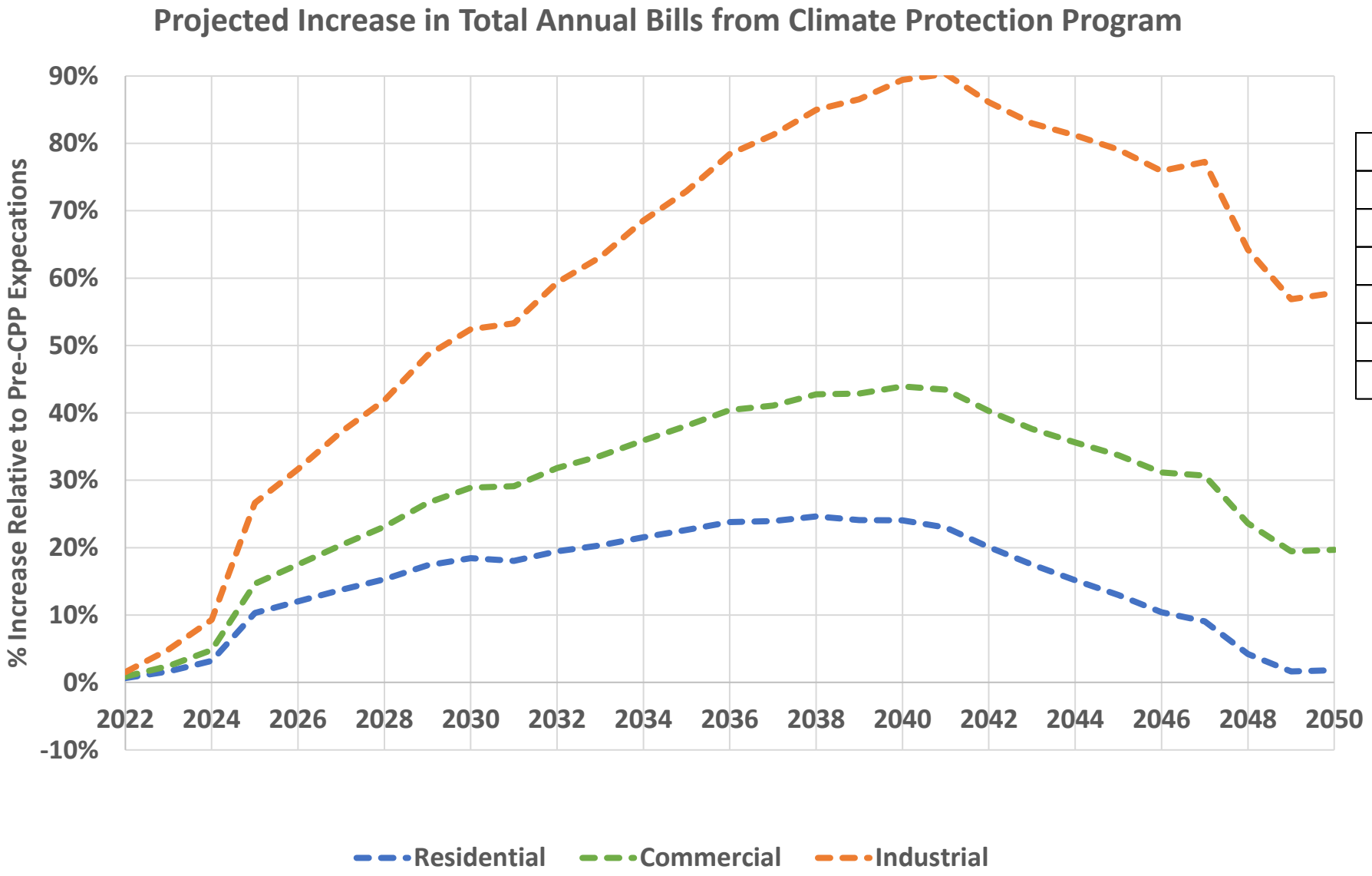






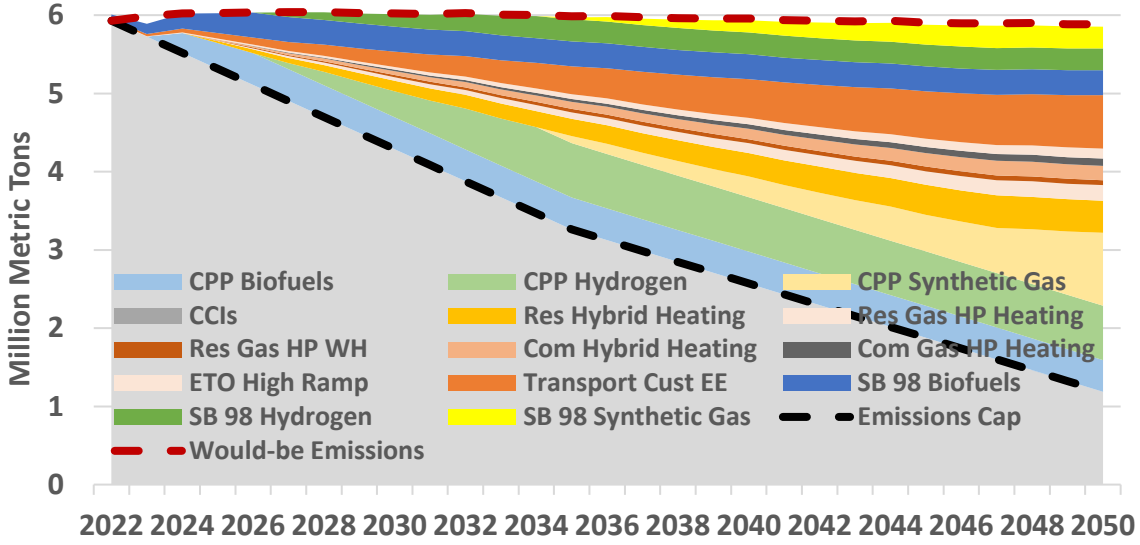


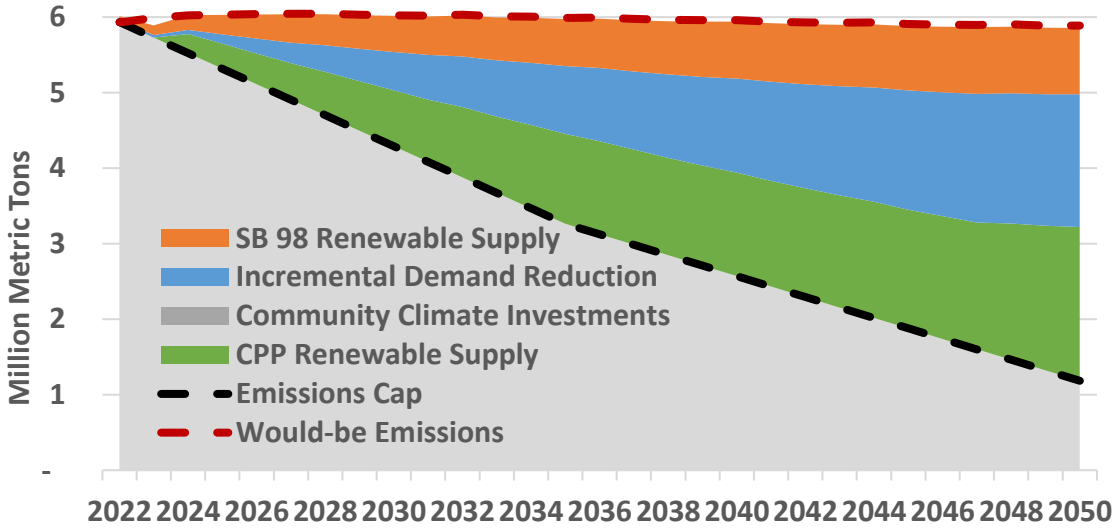
Aggressive Timeline Scenario- Bill Impacts

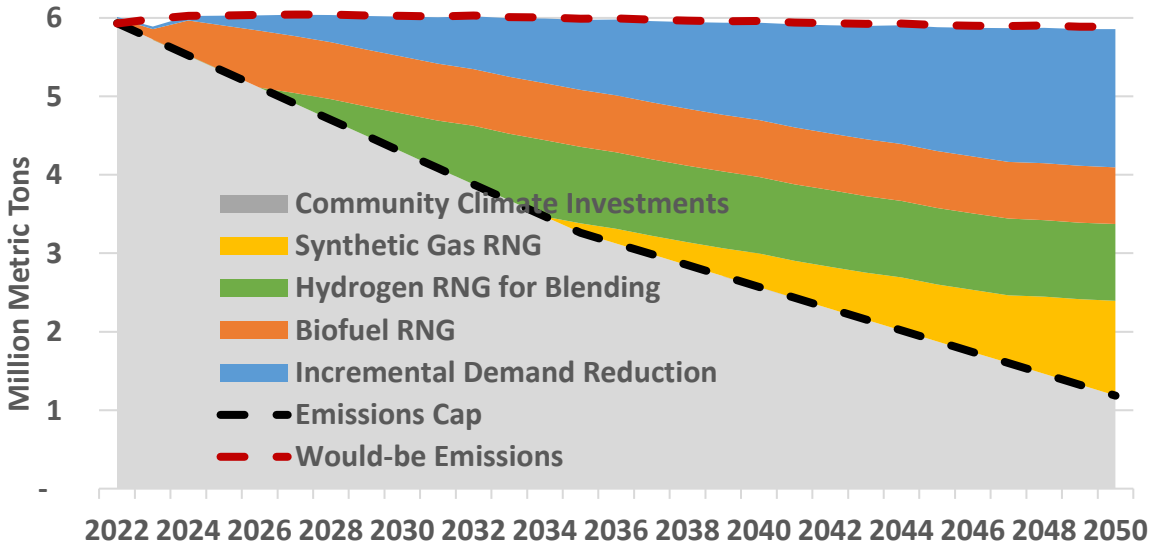


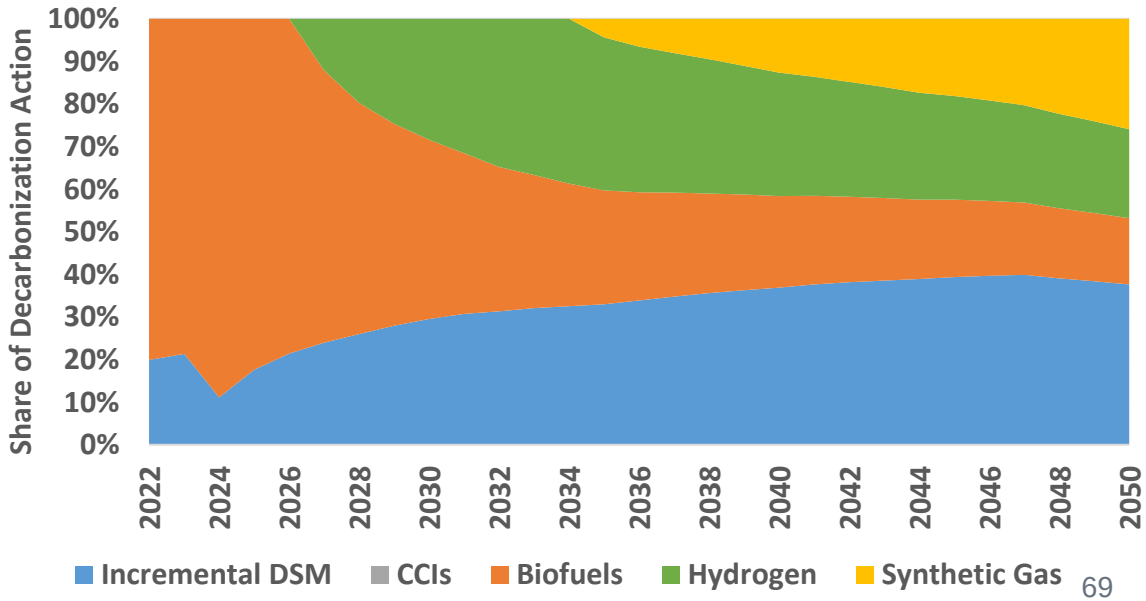
	Residential	Commercial	Industrial
2022	1%	1%	2%
2025	10%	15%	27%
2030	18%	29%	52%
2035	23%	38%	73%
2040	24%	44%	89%
2050	2%	20%	58%

No CCI Scenario- Key Results

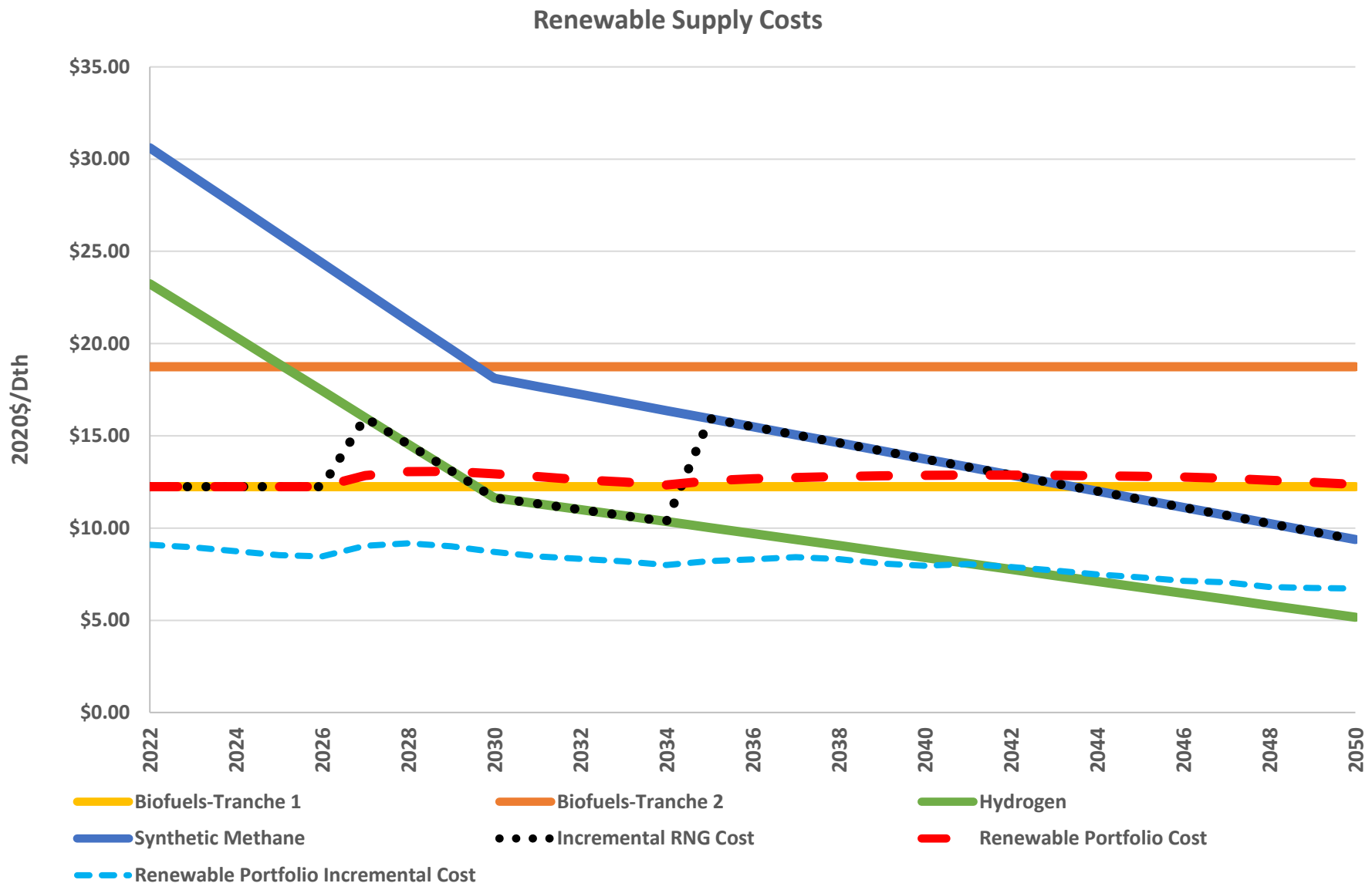




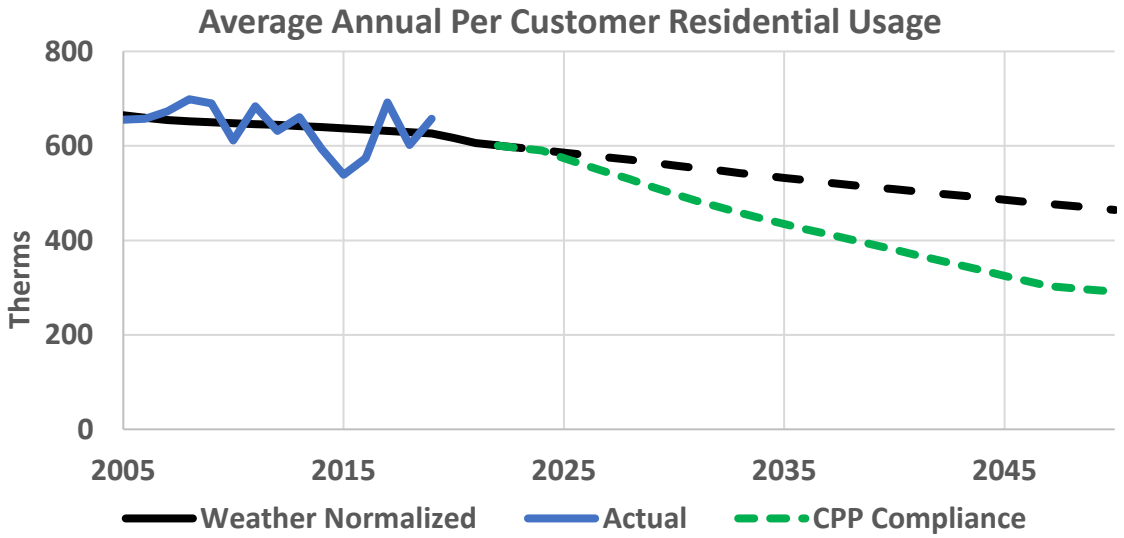


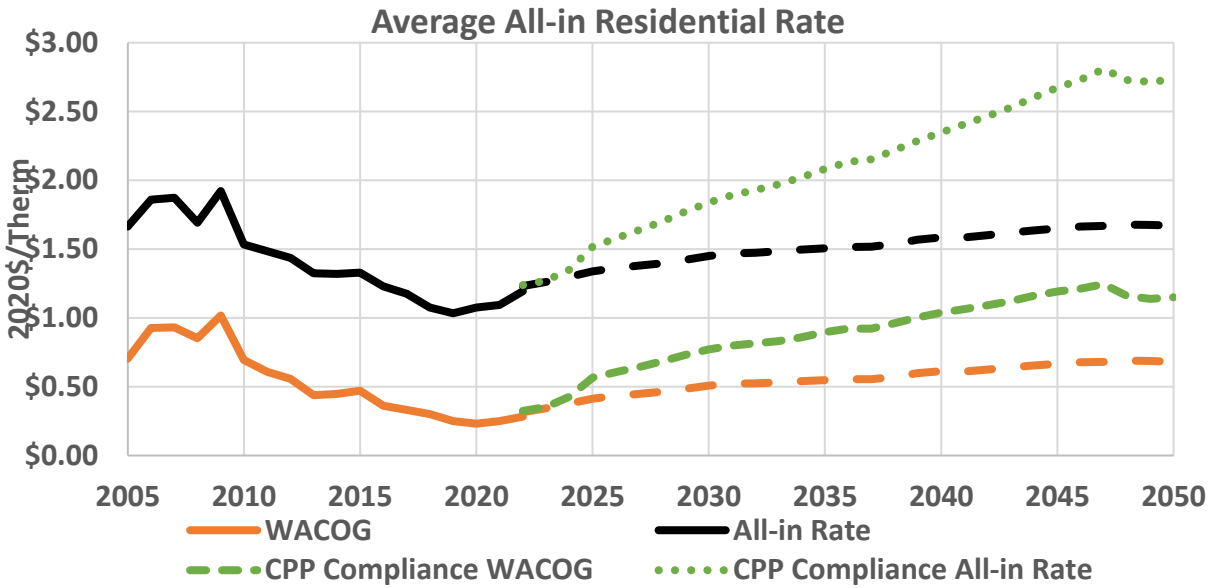


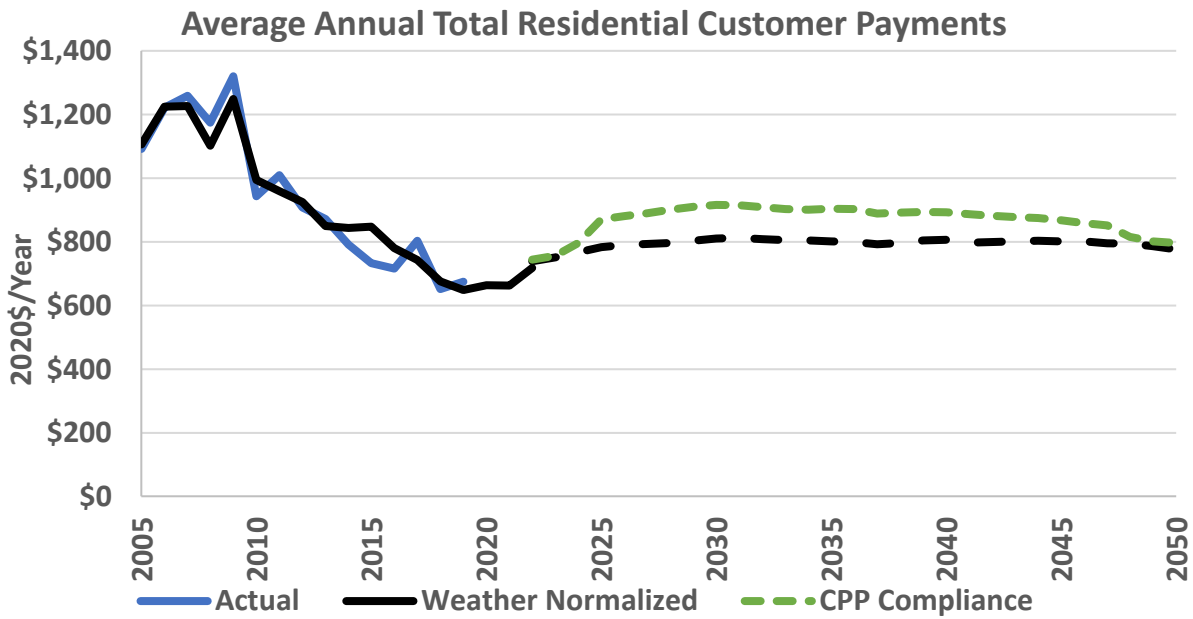
No CCI Scenario – Renewable Supply Results

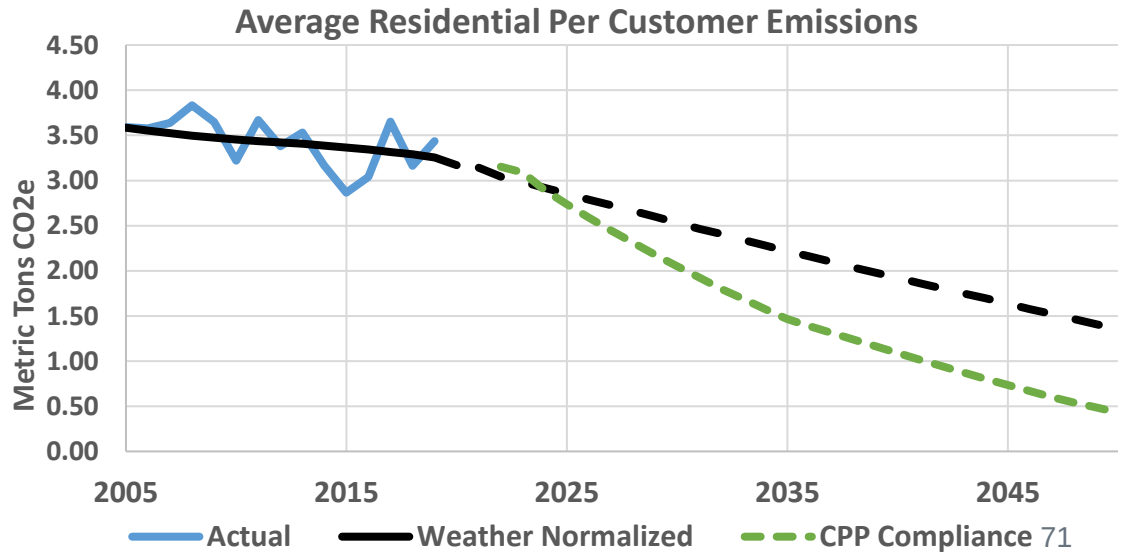


No CCI Scenario- Residential Results

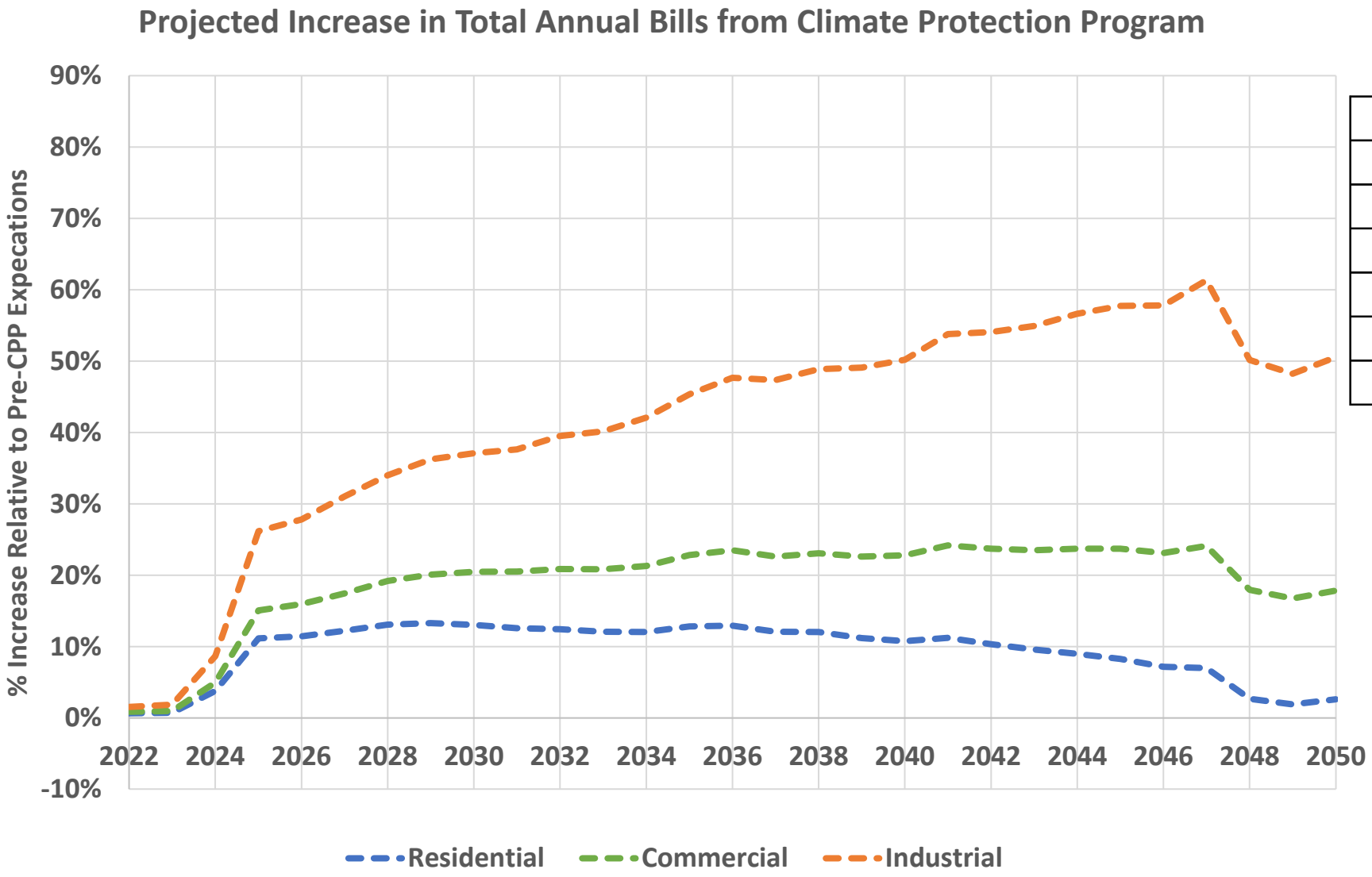








No CCI Scenario- Bill Impacts



	Residential	Commercial	Industrial
2022	1%	1%	2%
2025	11%	15%	26%
2030	13%	20%	37%
2035	13%	23%	45%
2040	11%	23%	50%
2050	3%	18%	51%

Hydrogen Next Steps

Blending Trials

- 5-20%vol hydrogen blend testing at Sherwood
- Hydrogen sourced (gray)
- Blending solution sourced
- Need to identify design & construction pathway
- Goal is to start blending by Q4/2021

Exploring System Readiness Audit

Safety

- At lower blends, characteristics of the gas are largely unchanged
  - Odorants
  - Upper and lower flammability limits
  - Leaks
- Hawaii Gas has 12% hydrogen blend with natural gas equipment
- Town gas has been used for decades – approx. 50% hydrogen
- 1,600 miles of hydrogen piping exists in the US today

Investigating Blue Hydrogen

Carbon Sequestration

- Investigating DOGAMI view of permitting, policies
- Black & Veatch high-level view of blue
  - Technologies
  - OPEX/CAPEX
  - Cost of delivered hydrogen (including 45Q)
  - Overall opportunity

Blue hydrogen looks very attractive

- NW Natural has a competitive advantage through its Mist work
- Low cost
- Low carbon intensity (2kgCO2(e)/kgH2 or less)
- Existing technology, significant storage in saline formations (400-5,500 yrs.)
- Possible mechanism for rapid generation of thermal credits
- New business development opportunities through gathering and/or sequestration of carbon for high-emission industries

Piloting Blending

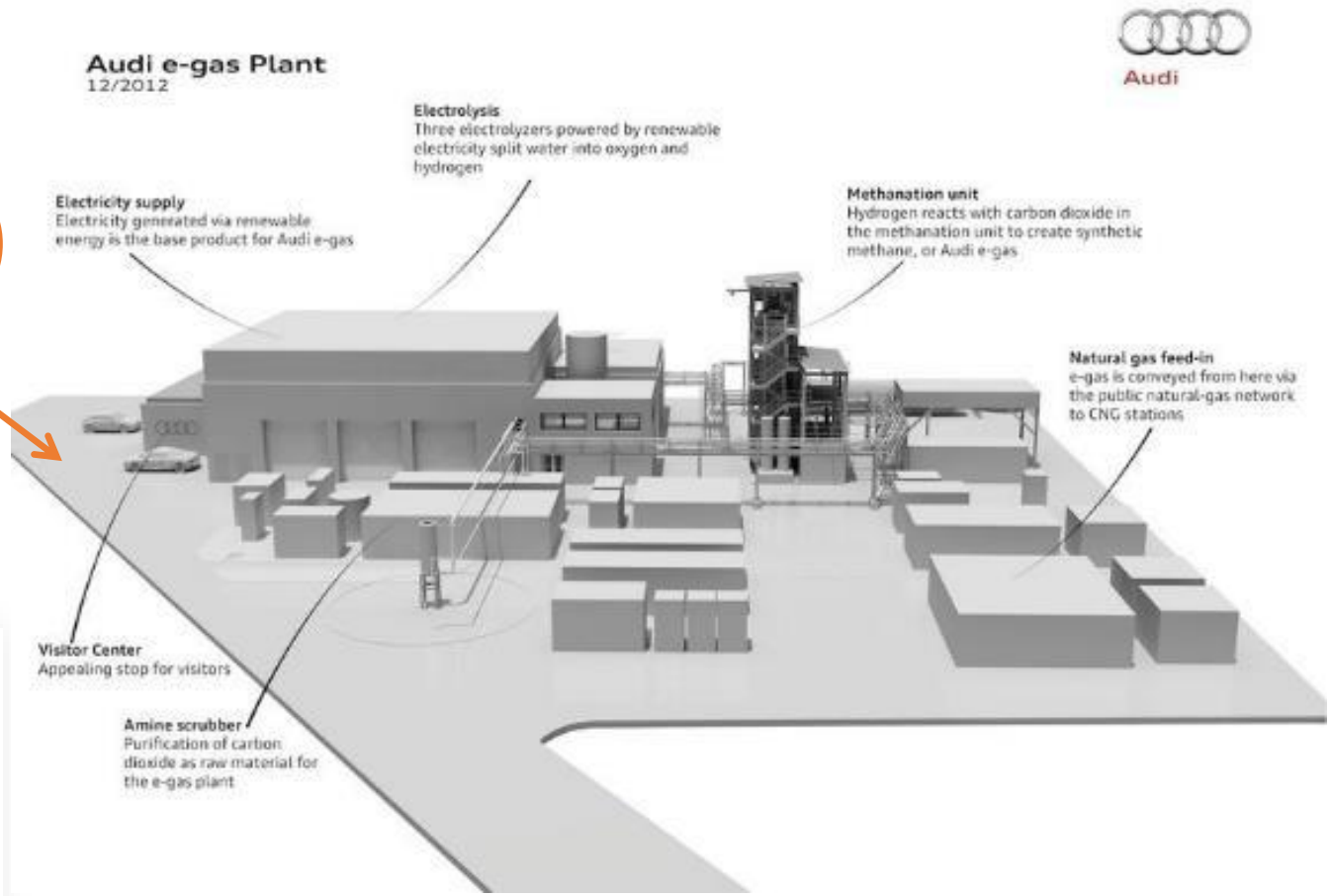
Partnering with EWEB and BEF on methanation project

- 1-2 MW demonstration plant
- Generating hydrogen from EWEB power, blending up to 5%

Looking at Short Mountain RNG (EPUD/Lane County) PtG addition w/biocatalyst

Power To Gas Methanation Project

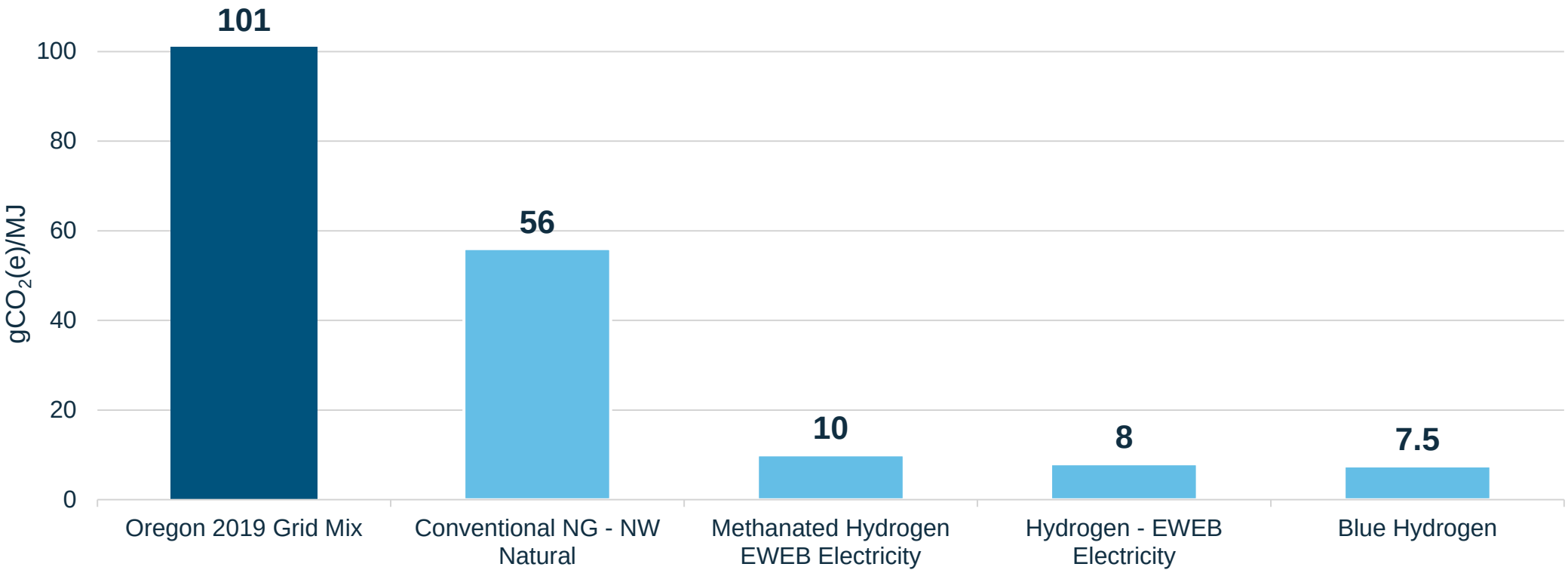
Source: Science Direct



Source: Green Car Congress

- Completed in 2013
- Hydrogen is created on site and combined with CO_2 (MAN chemical methanation)
- Methane is then injected into the natural gas grid

Carbon Intensities of Energy Sources



Estimates using power to gas efficiencies, Oregon DEQ, & California LCFS data

Preparing for Hydrogen

Safety is Paramount

- Material compatibility with pipes and components
- Appliance compatibility
- Different flammability characteristics
- Training, standard procedures

System and Customer Compatibility

- LNG
- MIST
- CNG

Energy Delivery

- Likely a maximum of 20% hydrogen (Wobbe)
- Translates to about 8% carbon savings
- Less with RNG
- At 12% falls below gas quality specification

Hydrogen Activities at NW Natural

5% Blending at Sherwood

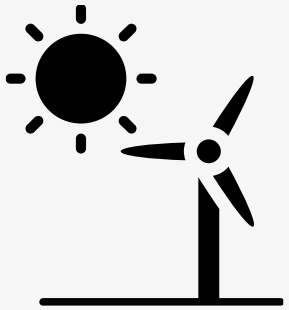
- Test rig
- Training town
- Sherwood buildings
- Customer trials
- System Injection

What is the right cost comparison?

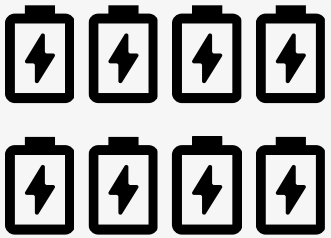
The total cost of reliable low carbon energy services delivered when customers need it.

Additional Investment Required Existing Infrastructure

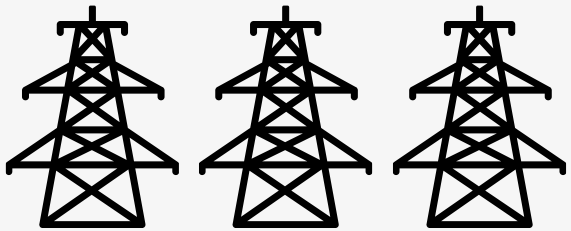
Wind & Solar



Battery



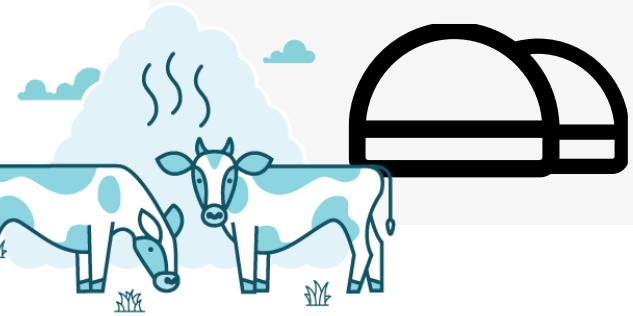
Transmission



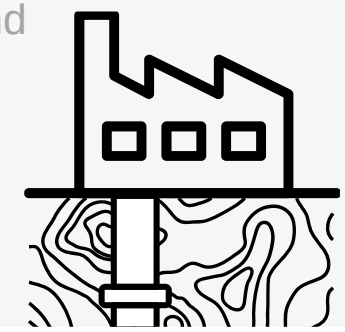
Customer

- Residential
- Industrial
- Commercial

RNG Digester



Underground Storage



Distribution