Guidehouse
Outwit Complexity

nationalgrid

CLCPA Study for KEDLI and KEDNY

Stakeholder Meeting – Draft Scoping Plan

July 13, 2022

Agenda

Introduction
Introduce Guidehouse

Project Overview
Review overall approach and project timeline

Analytical Approach
Benchmarking, model structure, scenarios, and outputs

Stakeholder Feedback and Q&A

©2022 Guidehouse Inc. All rights reserved.

Agenda

Introductions
Introduce Guidehouse team

Project Overview
Review overall approach and project timeline

Analytical Approach
Benchmarking, model structure, scenarios, and outputs

Stakeholder Feedback and Q&A

©2022 Guidehouse Inc. All rights reserved.

Introduction to Guidehouse

Trusted, global consultancy with broad relationships and skills

We combine our expertise with specialized resources and deep domain experience to **solve problems that cross sectors, industries and geographies** for clients of the public sector and the regulated commercial sectors they serve.

Formed via the merger of PwC Public Sector and Navigant Consulting, we blend management consulting flexibility with a deep energy and sustainability expertise.

We have a 30-year history of energy and sustainability work—having authored many of the standards that underpin footprinting and target setting.

Our Company

12,000+ employees and subject matter experts

50+ locations globally

Malcolm Baldrige National Quality Award

33 languages fluently spoken

10 HRC consecutive perfect scores

BEST PLACES TO WORK 2019 for LGBTQ Equality 100% CORPORATE EQUALITY INDEX

Committed to **Science Based Targets** to reduce our greenhouse gas emissions

Our Clients and Team

Financial Services:

8/10 of the largest US banks

Life Sciences:

38 of the top 50 pharmaceutical companies

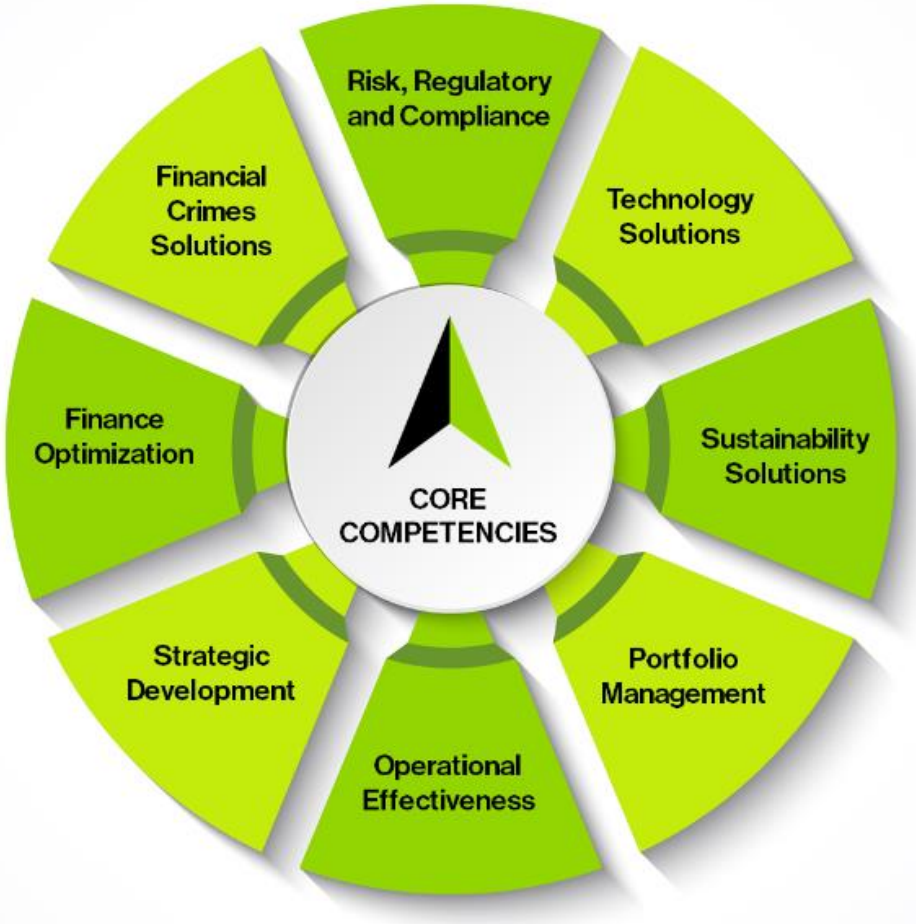
Energy:

60 of the world's largest electric and gas utilities***

15/15 departments of the Federal Government

1000+ energy consultants

100+ sustainability consultants



©2022 Guidehouse Inc. All rights reserved.

Guidehouse will apply learnings from prior Low Carbon Pathways studies

- In the energy transition, decarbonization of electricity and gas systems will become increasingly interdependent.
- Analysis of emissions reduction pathways requires modeling interactions between the electricity and gas energy systems.
- For example, electric networks must be sized and with generation capacity for hydrogen production, and hydrogen may be used in dispatchable gas turbines to meet peak electric demand.

*"Network development plans should be based on a **joint scenario for electricity, gas and hydrogen."***

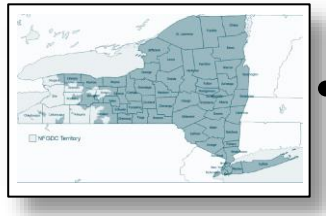
Source

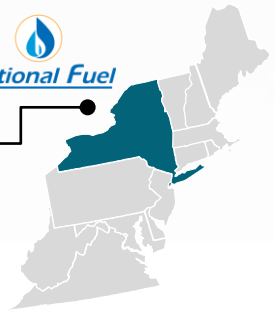
European Commission

Our integrated energy system experience across these jurisdictions gives us a **unique perspective** and **lessons learned** on **decarbonization** pathways for electric and gas utilities.

New York

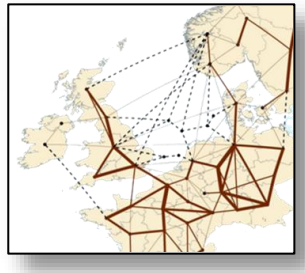
National Fuel





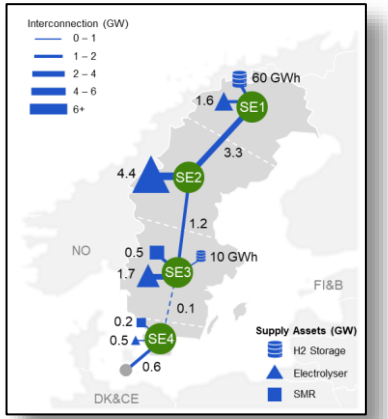
North Sea

North Sea Wind Power Hub



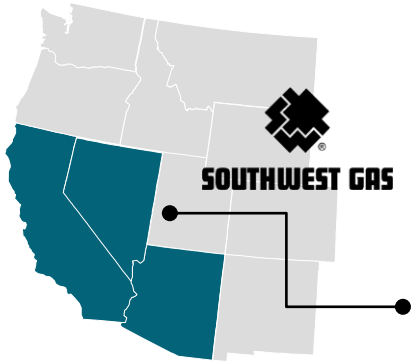
Sweden

NORDION ENERGI



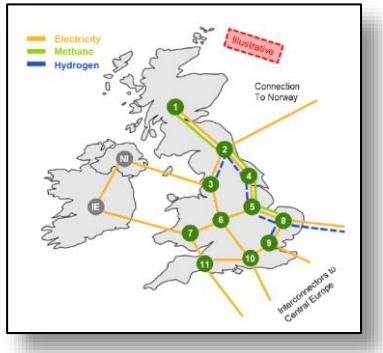
NV, AZ & CA

SOUTHWEST GAS



UK

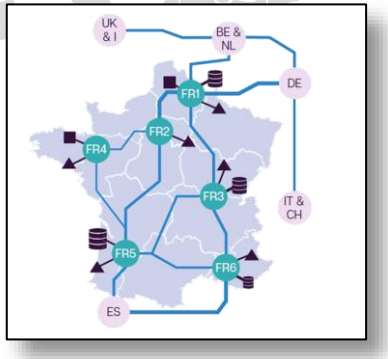
nationalgrid
Electric and Gas



France

GRTgaz

TERĒGA



Guidehouse Outwit Complexity

©2022 Guidehouse Inc. All rights reserved.

Agenda

Introduction
Introduce Guidehouse

Project Overview
Review overall approach and project timeline

Analytical Approach
Benchmarking, model structure, scenarios, and outputs

Stakeholder Feedback and Q&A

©2022 Guidehouse Inc. All rights reserved.

Key Questions for the CLCPA Study

1. What are the outcomes and feasibility of implementing various scenarios to achieve New York's state (CLCPA) and local (LL97) climate goals and meet the Climate Act emissions requirements?
2. What projects and programs could be implemented in National Grid's service territory to help achieve these emissions requirements?
3. How could implementation of these scenarios impact costs, policy, public health and other qualitative factors for National Grid's customers, especially those in disadvantaged communities?
4. What are the potential barriers to achieving the CLCPA targets and what are some solutions to combat those barriers?

Stakeholder feedback will guide how these questions are addressed and will provide additional territory-specific considerations for this study.

©2022 Guidehouse Inc. All rights reserved.

Overall Approach

Review Studies

- Review studies and document key assumptions

Decarbonization Pathways Analysis

Development of three scenarios	Data collection and input development	Low Carbon Pathways (LCP) Modeling
Costs and GHG emission reductions	Programs and projects to achieve modeled reductions	Cost recovery, equity, affordability considerations

Reporting

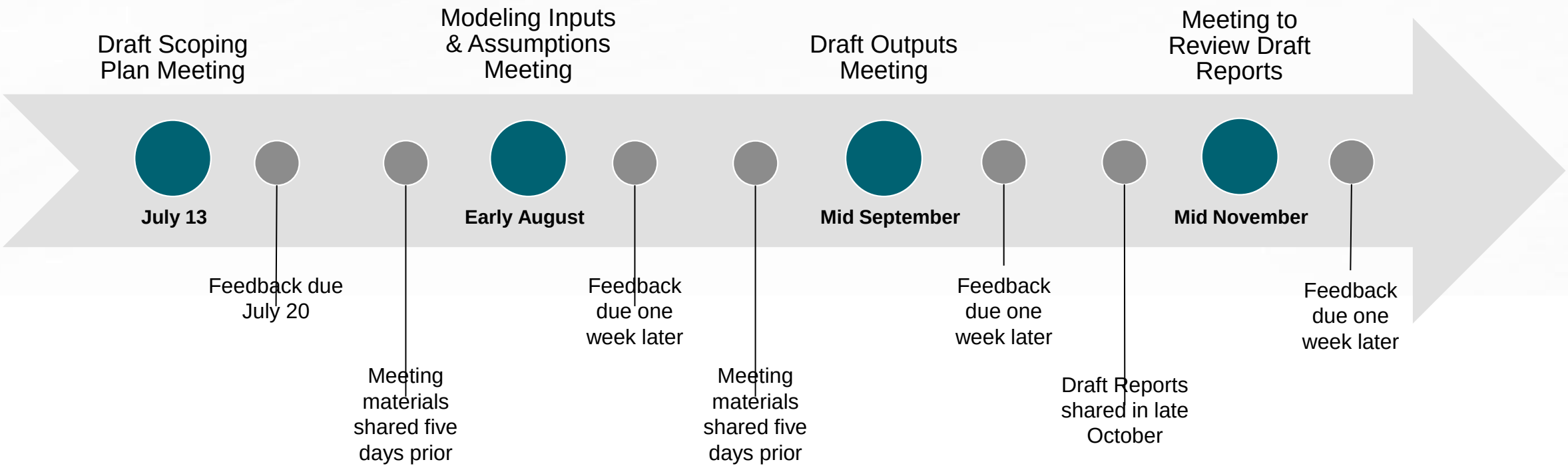
- Upstate and Downstate Reports will include:
  - Scenario Demand Forecasts
  - Outcomes from the Pathways Analysis
  - Qualitative Implications of this Assessment

Stakeholder Engagement

1. Study Scope (July 13)
2. Study Assumptions (early August)
3. Draft Study Outputs (mid September)
4. Draft Reports (mid November)

©2022 Guidehouse Inc. All rights reserved.

Key Stakeholder Engagement Dates



The exact dates and timeframes shown are flexible. We will seek to give as much advance notice on exact dates as possible.

©2022 Guidehouse Inc. All rights reserved.

Agenda

Introduction
Introduce Guidehouse

Project Overview
Review overall approach and project timeline

Analytical Approach
Benchmarking, model structure, scenarios, and outputs

Stakeholder Feedback and Q&A

©2022 Guidehouse Inc. All rights reserved.

Review of Decarbonization Studies

Key Studies to Inform Pathways Modeling

- Guidehouse examined recent decarbonization studies focusing on items in the table below.
- Guidehouse compared the scope, methodology, assumptions, and results of these studies
- Goals were to:
  - Understand the fundamental policy and economic drivers that shaped scenario development
  - Identify areas of alignment and leverage key assumptions from prior analyses

Title	Organization	Year	Report / Webpage Link
Climate Scoping Plan and Integration Analysis	NY Climate Action Council	2022	Link
MA DPU 20-80 Proceeding (E3 Study and National Grid report filed March 18, 2022)	MA Gas LDCs	2022	Link
Pathways to Deep Decarbonization in New York State	New York State Energy Research Development Authority (NYSERDA)	2020	Link
Massachusetts 2050 Decarbonization Roadmap	Massachusetts Executive Office of Energy and Environmental Affairs	2020	Link
… and other recent decarbonization studies covering NY and New England			

©2022 Guidehouse Inc. All rights reserved.

Modeling Approach – Low Carbon Pathway (LCP)

"What if?" modeling finds lowest-cost path to scenario outcomes

LCP Model Configuration to NY

The LCP model is an integrated capacity expansion and dispatch optimization model used to identify the lowest-cost pathway to a decarbonized energy system (electric and gas).

Different scenarios and sensitivities can be easily evaluated.

Geographic Scope: NY & neighboring regions

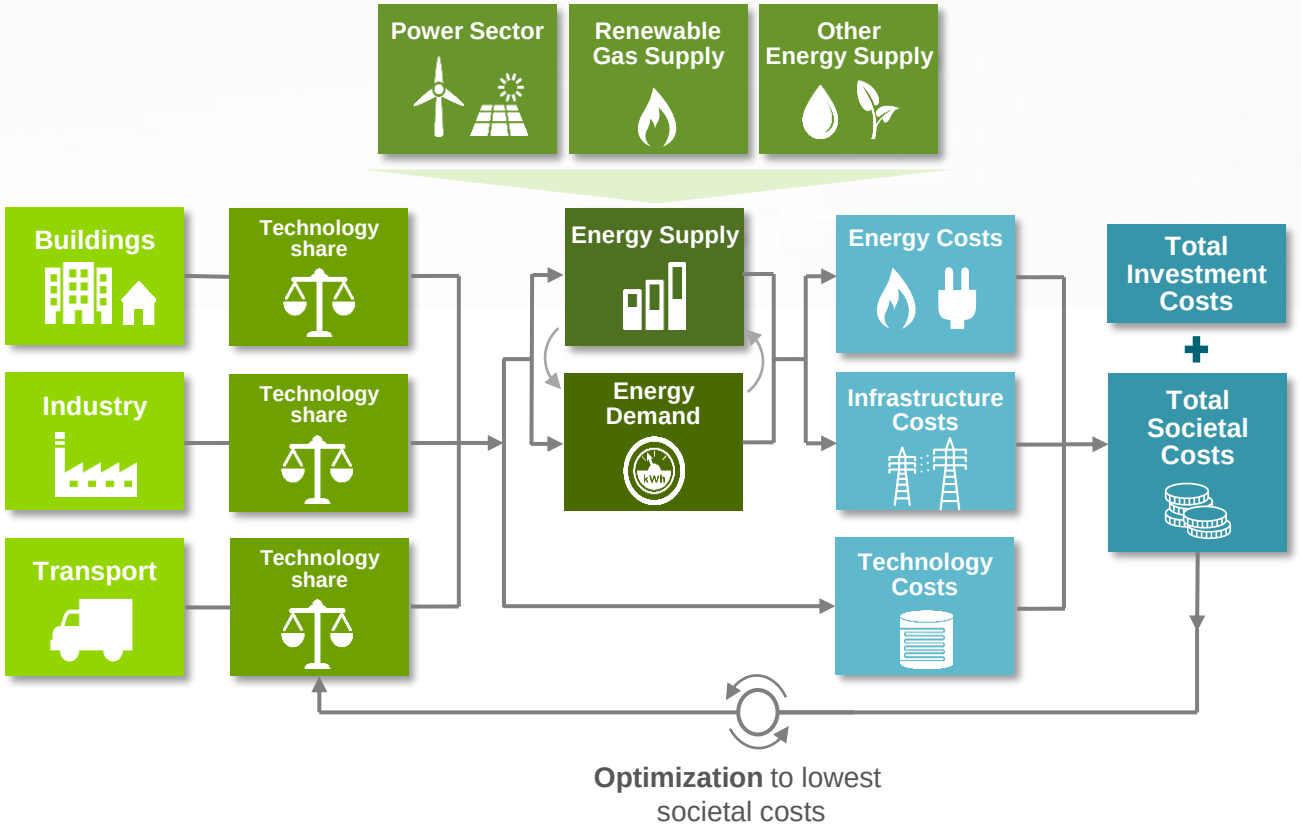
Energy Carriers:
- Electricity
- Hydrogen
- Methane

Investment Types:
- Infrastructure & supply capacity
- Elec/Gas Storage
- Conversion techs (e.g., electrolyzers)

LCP Model Key Outputs

- Low-carbon and renewable gas quantities over time (green hydrogen, blue hydrogen, RNG, etc.)
- Energy system costs including gas and electric network investments:
- Supply capacity (onshore/offshore wind, electrolyzers, SMR, etc.)
- Transmission Interconnections (transmission lines, new/retrofit pipelines, etc.)
- Storage assets (hydrogen storage, battery storage, etc.)
- Timeline of investments (2025, 2030, 2035, 2040, 2045, 2050)

Model Design



©2022 Guidehouse Inc. All rights reserved.

Modeling Approach – Demand Forecasting

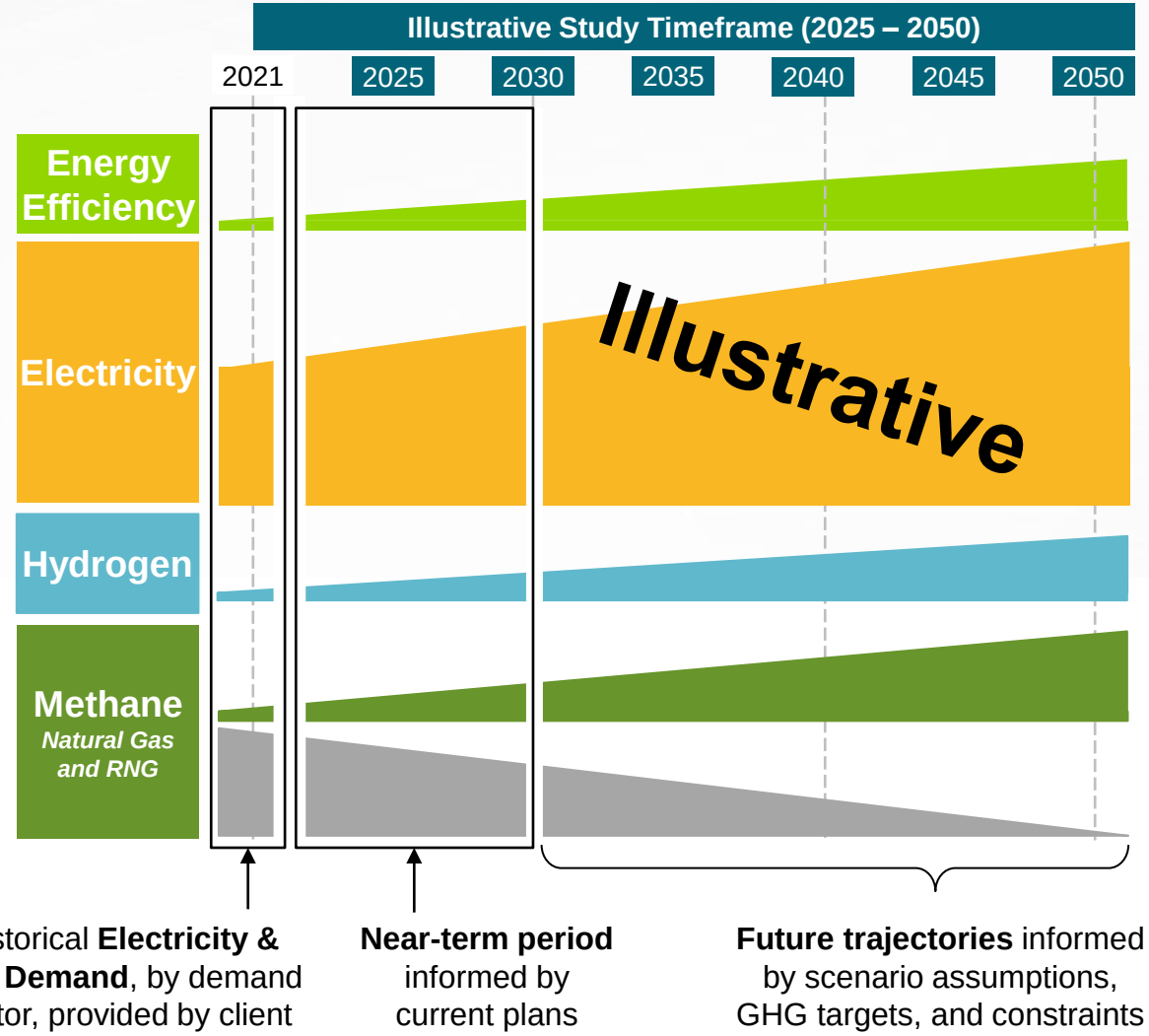
1 | Characterize base year – Establish historical electricity and gas demand, for each demand sector (buildings, transport and industry) in each region.

2 | Incorporate Planning Inputs – Include supply- and demand-side assumptions and inputs from clients' recent plans (e.g., capacity additions, planned retirements, interconnection projects, etc.) as "planned" or "expected" investments. Account for energy efficiency programs.

3 | Develop decarbonization scenarios – Each scenario has assumptions for the demand sectors (*e.g.*, 90% of residential building heating is electrified).

Note: Region-specific adjustments can be applied to individual sectors, to account for regional variations like climate, buildings mix & industry mix.

4 | Develop supply and demand sensitivities – Different scenario variations can be tested to answer questions like, "What if hydrogen costs are higher/lower than expected?" or, "What if new pipelines are disallowed?"



©2022 Guidehouse Inc. All rights reserved.

Modeling Approach – LCP Model Overview

OBJECTIVE FUNCTION

The model's primary objective function is to minimize energy system costs over the analysis horizon (e.g., 2020-2050) – including supply, infrastructure, and demand costs.

Supply Costs

- Cost of new entry. (CONE)
- Fixed O&M. (FOM)
- Variable O&M. (VOM)
- Fuel cost.
- Emissions cost.

Infrastructure Costs

- CONE, FOM, VOM by energy carrier. (electricity, CH4, H2, heat)
- Both inter- and intraconnections are considered.

Demand Costs

- Demand technology costs.
- Others as needed.

DECISION VARIABLES

The model determines the optimal capacity and dispatch for supply and infrastructure, as well as the optimal mix of demand-side technologies.

Supply Tech Capacity & Dispatch

- Installed cap. by supply tech, year, region.
- Fossil gen, renewables, crossloads, short- and long-term storage.
- Energy dispatched by supply tech, year, season, hour, region.

Infrastructure Capacity & Dispatch

- Installed capacity by energy carrier, region, year.
- Energy transferred by energy carrier, region, season, timestep, year.

Demand Technology Mix

- Gas boilers/furnaces
- District heating
- CHP

CONSTRAINTS

The model is constrained by existing and planned supply and infrastructure capacity, interim & final emissions reduction targets, and balancing energy supply and demand.

Emissions

- Total emissions are <= the target.
- Targets can be set by year.

Supply & Infrastructure Capacity

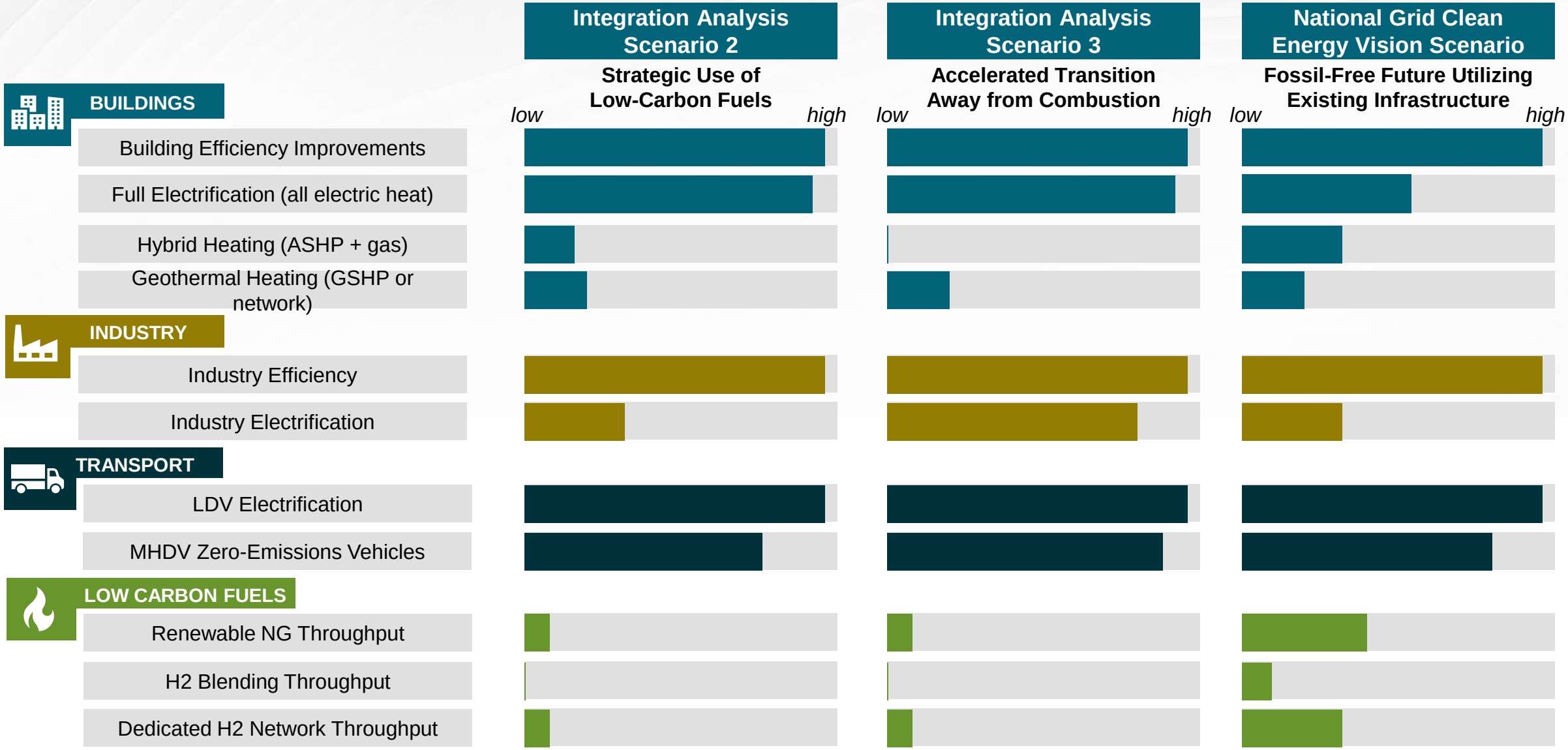
- MaxSupply Capacity: by supply tech, region, and year.
- Sufficient Infrastructure Capacity: by energy carrier, region, and year.

Energy Balance

- Demand = Supply
- Electricity, CH4, H2, Heat
- Energy is balanced by energy carrier, year, season, hour, and region.

©2022 Guidehouse Inc. All rights reserved.

Summary of Scenario Parameters



©2022 Guidehouse Inc. All rights reserved.

Key LCP Model Outputs

- GHG emissions over time
- Gas supply over time (energy and volume)
- Low-carbon and renewable gas quantities over time (green hydrogen, blue hydrogen, RNG, etc.)
- Electric and gas peaks over time
- Distribution network / infrastructure
- Energy system costs including gas and electric network investments
- Supply capacity (onshore/offshore wind, electrolyzers, SMR, etc.)
- Transmission Interconnections (transmission lines, new/retrofit pipelines etc.)
- Storage Assets (hydrogen storage, battery storage, etc.)
- Timeline of investments (2025, 2030, 2035, 2040, 2045, 2050)

©2022 Guidehouse Inc. All rights reserved.

Final Report Overview

Scenario Demand Forecasts

- Description of the different scenarios included in the analysis
- Description of how demand for different energy carriers evolves over time for various sectors

Outcomes from the Pathways Analysis

- Discussion of GHG results over time and the feasibility of achieving CLCPA targets for each scenario
- Electric and gas supply development
- Comparison of energy system costs by scenario

Qualitative Implications of this Assessment

- Qualitative discussion of impacts on customers including affordability, reliability, costs, policy, equity, public health, customer bill impacts, customer practicality, economic development and more
- Discussion of potential projects and programs to achieve NY climate goals
- Discussion of any barriers to implementation and potential mitigation strategies

©2022 Guidehouse Inc. All rights reserved.

Agenda

Introduction
Introduce Guidehouse

Project Overview
Review overall approach and project timeline

Analytical Approach
Benchmarking, model structure, scenarios, and outputs

Stakeholder Feedback and Q&A

©2022 Guidehouse Inc. All rights reserved.

Areas for Stakeholder Feedback

Are you aware of resources or studies that the Guidehouse team should consider?

Are there specific approaches to decarbonization that you would like to see included in the study?

What specific issues or questions do you think are most important to include in these reports?

©2022 Guidehouse Inc. All rights reserved.

Questions?

©2022 Guidehouse Inc. All rights reserved.