Seminar 57 – Multiscale Building Energy Modeling, Part 9

David Shipley

Posterity Group

Shipley@posteritygroup.ca

343-488-8282

Using Regional Building Modeling for Energy Forecasting

Learning Objectives

- Objective 1: Provide an overview of Urban Building Energy Model (UBEM) techniques and data sources.
- **Objective 2: Describe the use of regional building modeling as a forecasting tool, especially as it relates to critical uncertainties in data assumptions and how they can be handled.**
- Objective 3: Demonstrate the ability of 3D mapping techniques to provide wide-area geometrical information over urban and foliated scenes with evaluation of critical infrastructure (e.g. power line damage and flooding).
- Objective 4: Describe an approach for community-scale modeling using detailed whole-building energy models with use cases for district system optimization.

Acknowledgements

Ken Ross, David Bailey, and Robert Schuster

FortisBC – Natural Gas

Outline/Agenda

- Energy forecast users and their needs
- Forecasting for a BC utility
- Modeling approach
  - Building archetype modeling
  - Multiple scenarios modeling
- Results
- Conclusions

Energy Forecast Users

- Regulated electric and gas utilities
- Independent system (grid) operators
- Governments

Forecast User Needs

- Planning for future energy resource needs
- Planning system infrastructure based on local peak loads
- Estimating future revenue
- Managing compliance with future emission restrictions
- Estimating potential energy savings or peak reductions from technologies or programs

Needs: Short-term vs. Long-term

- Short-term forecasts use:
  - Sophisticated dispatch models for the electric grid and sources of supply

    OR
  - Sophisticated hydraulic models for gas distribution
- Energy end uses rarely change fast enough to affect three-year forecasts (or the peak load during a commercial)
- In the long term (20 years) energy end uses change!

Forecasting Project for a BC Utility

- Client is the main gas company serving British Columbia
- Gas service territory is the blue and olive green areas at left
- Regulated by the BC Utilities Commission
- Modeling supported the filing of their 2017 Long Term Gas Resource Plan

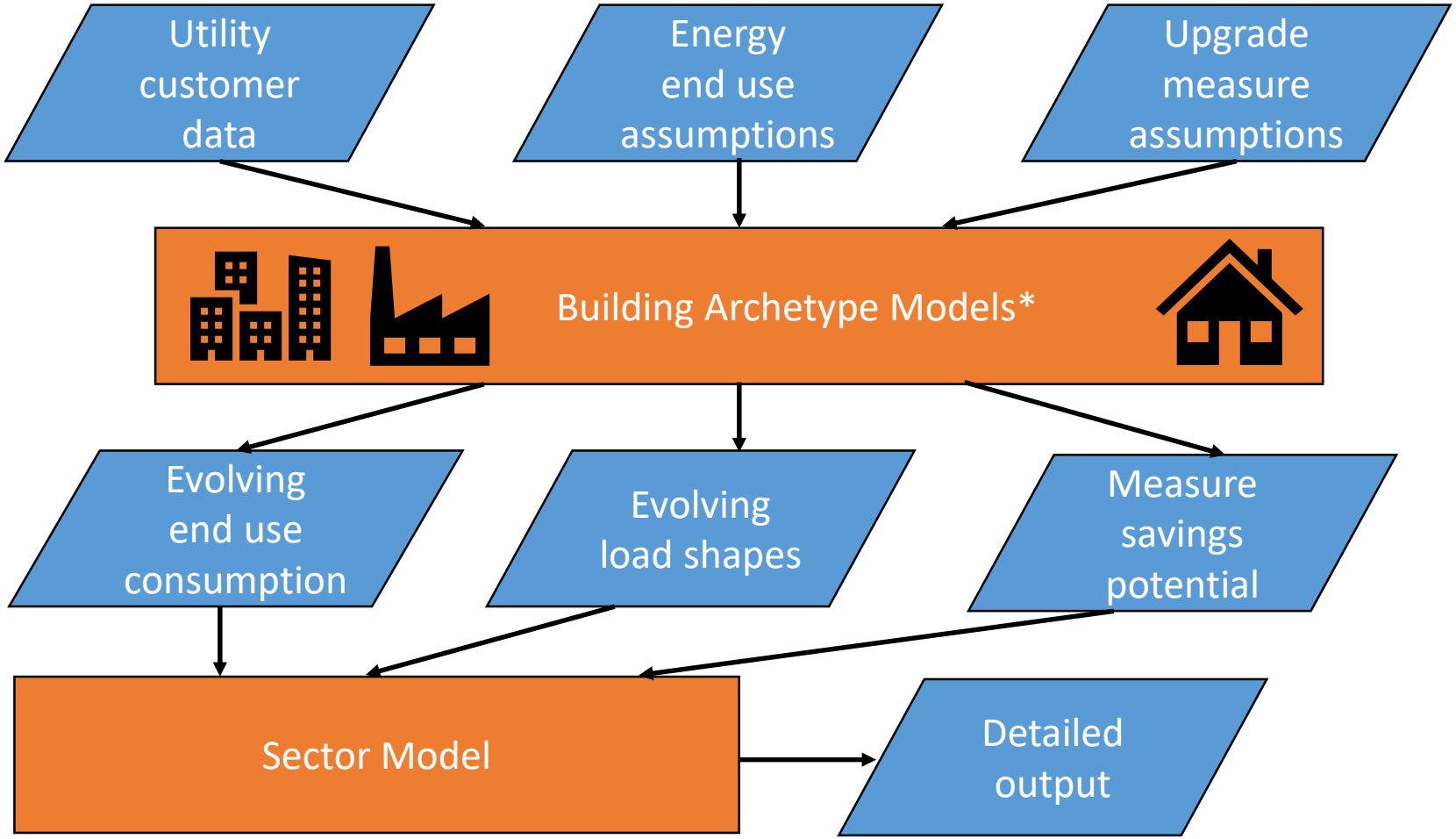
Map is from 2017 Long Term Gas Resource Plan, FortisBC Energy Inc.

Client Objectives

- Develop robust long term plans that will work in a range of possible futures
  - If demand is more than planned for, the utility may fail to meet its regulated “obligation to serve”
  - If demand is less than planned for, revenue may fall short of paying for infrastructure costs
- Manage risks from error and uncertainty:
  - Error from not understanding changing energy uses
  - Uncertainty from assumptions

Caveat: Presentation of results is limited to numbers included in tables or charts in the 2017 Long Term Gas Resource Plan.

Modeling Approach



* Developed by another consultant

Why Use Building Archetype Modeling?
- Input Data

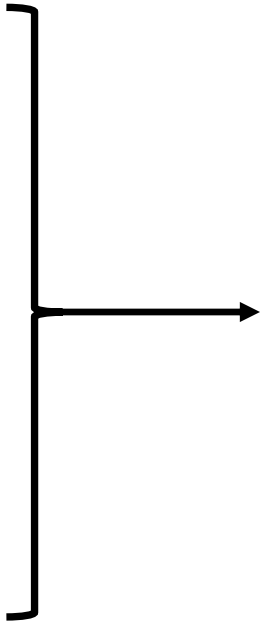
- Customer data (counts & energy) is aggregated by region, rate class, and NAICS code categories
- End use surveys of energy-using equipment have granularity limited by sample size
- Building starts data and population projections are province-wide
- Future energy pricing is by fuel
- Energy upgrade measures have hundreds of permutations

Modeling needs to accommodate input data
with different granularities

Why Use Building Archetype Modeling?
- The Need for Speed

We need:

- Estimate energy end use breakdown
- Estimate load shapes
- Estimate energy efficiency potential

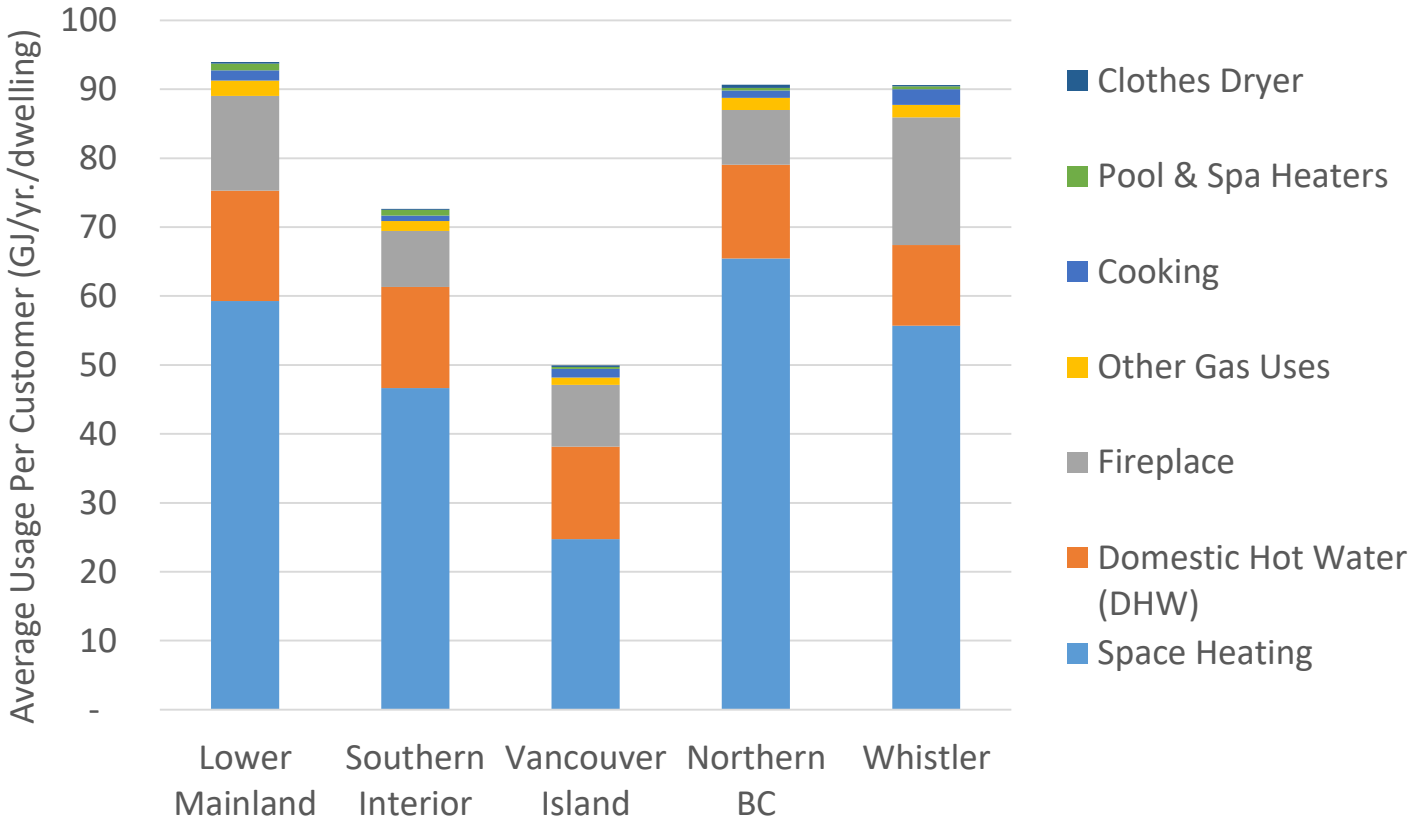


- Now
- Over 20 years
- Under multiple sets of economic assumptions

Multiple Scenarios + Need for Speed (and no super computer)
= Archetype Models

Modeling Results:

Residential Base Year Usage per Customer



Building Models Can Help Reduce Error

- Segment residential by house type and vintage
  - Ground-truth against measured data, submetering, and expert knowledge
- Segment commercial and industrial by rate class and by building or plant type*
  - Compare C/I results against audit data or industry experts
- Compare annual whole building consumption against metered averages
- Use monthly values to confirm end-use breakdown

* Energy end use detail available to client, but cannot be presented here due to customer confidentiality.

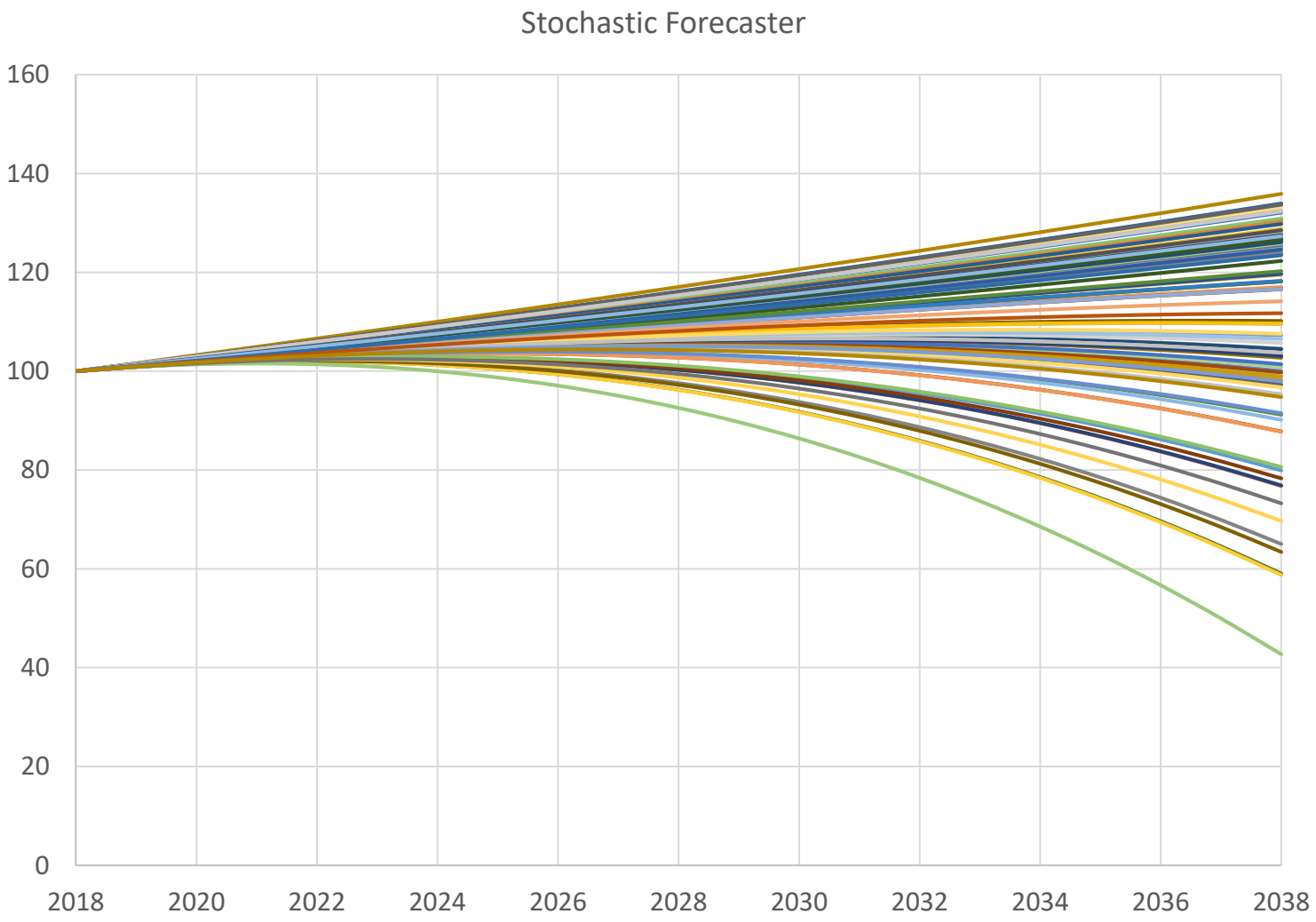
Why Use Multiple Scenarios?

- Assumptions about the future are inherently uncertain:
  - Growth
  - Relative fuel cost
  - Carbon pricing
  - Future codes and standards
  - Technological change

Managing Uncertainty from Assumptions

- Improve quality of assumptions by using the most credible forecasting sources
- Run scenarios changing only one major assumption to assess sensitivity
- Estimate upper and lower bounds for assumptions and run scenarios exploring the range
- Run stochastic, Monte Carlo scenarios where the input assumptions vary randomly according to probability distributions (see next slide)
  - Shows the low likelihood of extremes combining

Stochastic Forecasting Example



How We Used Multiple Scenarios in This Project

- Ran parallel “what-if” scenarios with specific sets of assumptions:
  - Six scenarios for future gas demand from the traditional customer base
  - Three scenarios for future natural gas transportation
- Client developed the “story line” for each scenario
- Consultant developed numerical assumptions to tell the story
- Also ran some “goal seeking” scenarios:
  - What combinations of inputs need to change to reach a GHG reduction goal by a specific year?

Output Retains Full Granularity

Scenario Analysis:

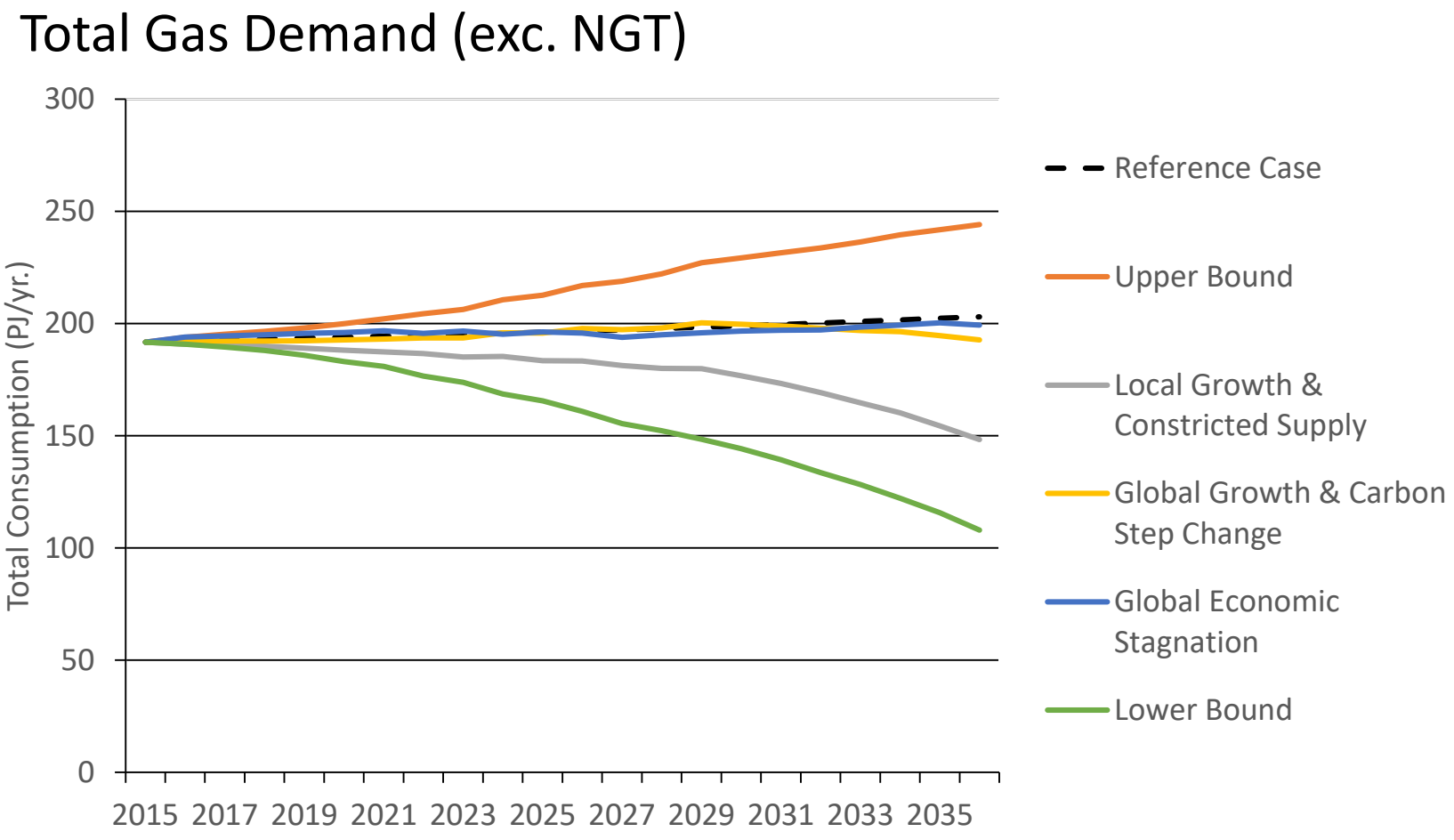
6 scenarios × 20 years × 5 regions × 4 sectors × 6 fuels × 18 rate classes × 40 building types × 33 end uses = 6 million rows

Savings Potential Analysis:

420 residential measures
+
1504 commercial measures
+
728 industrial measures

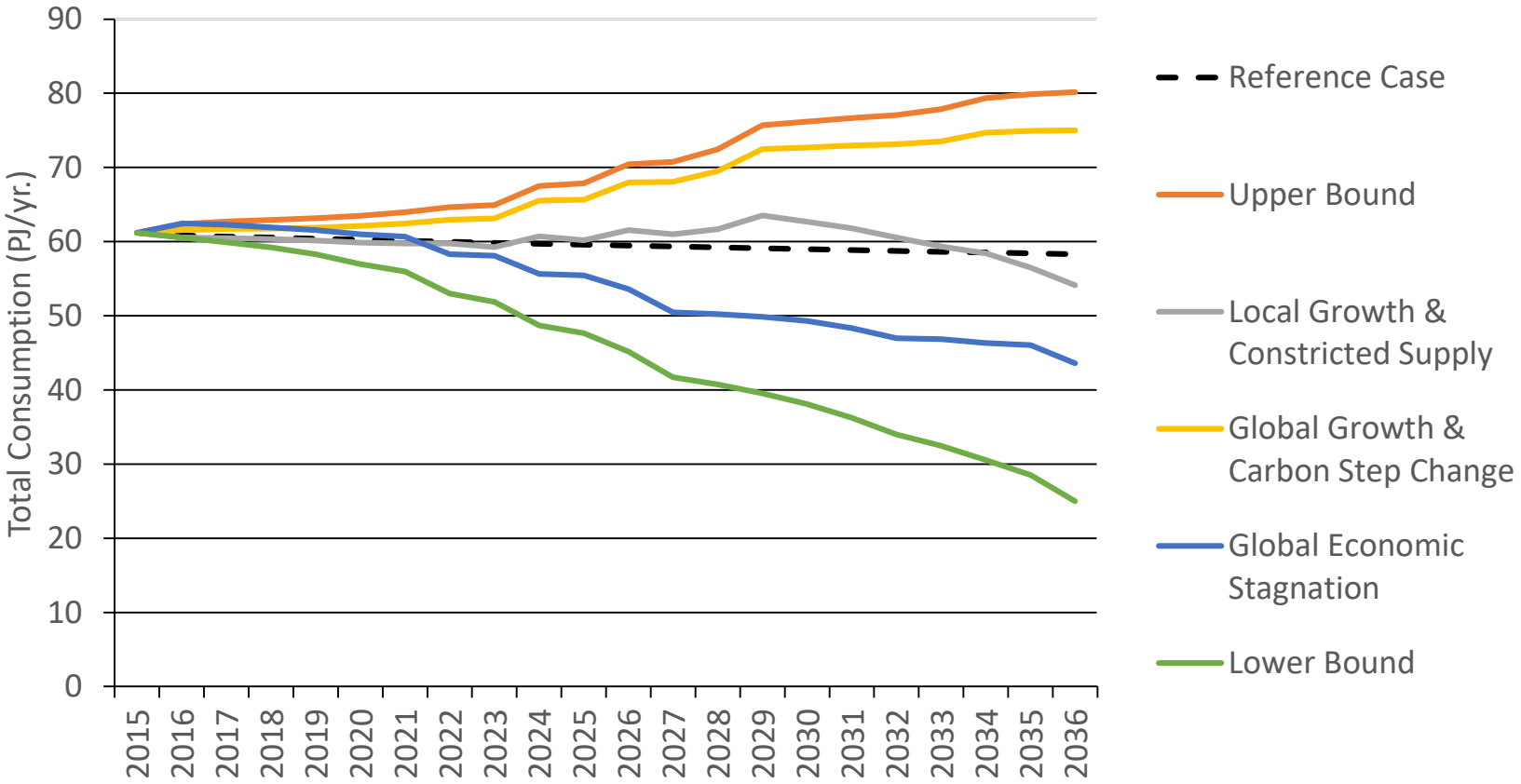
× Savings potential for gas only = 3 million rows

Results:

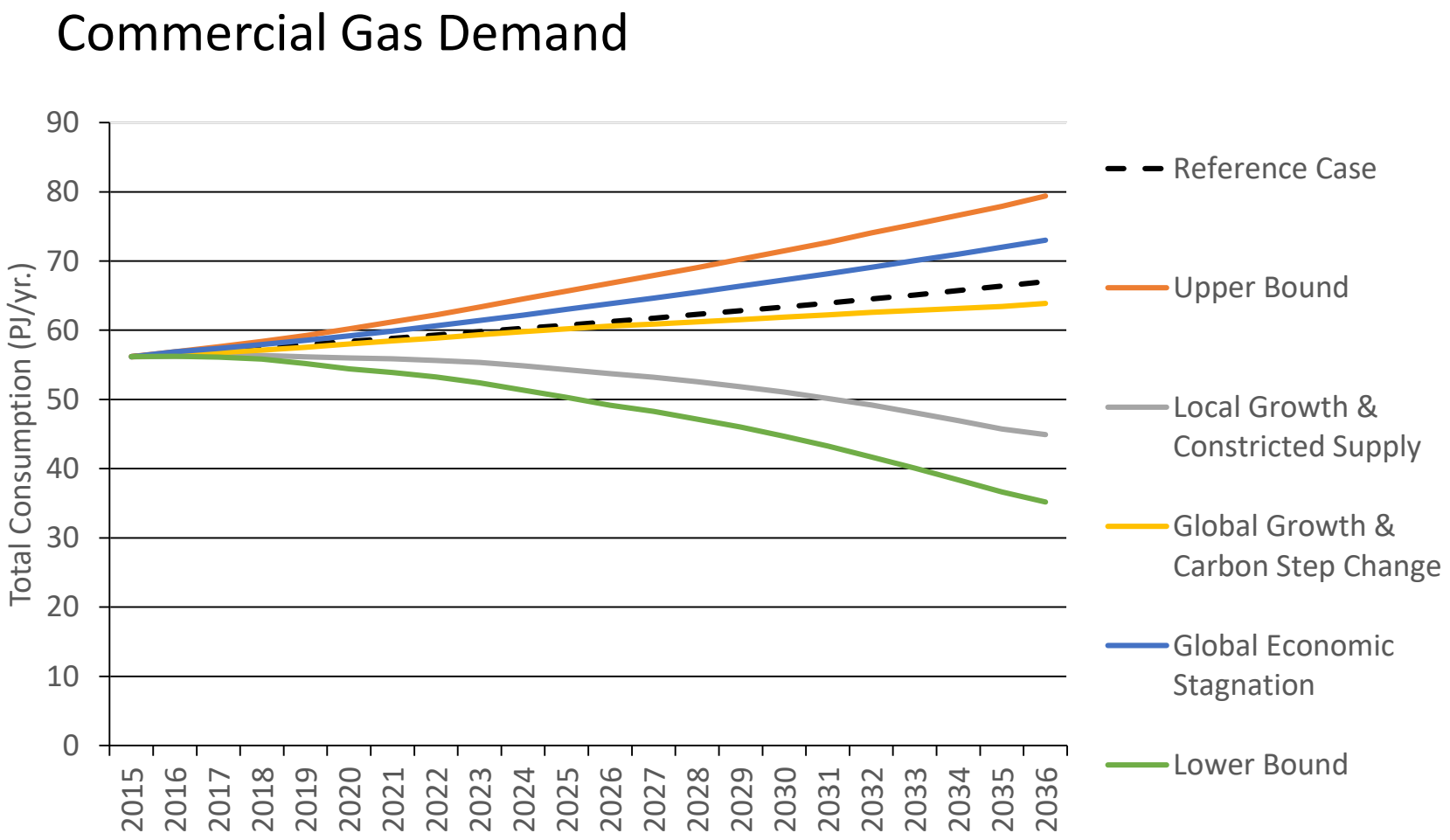

Total Gas Demand (exc. NGT)
Total Consumption (PJ/yr.)
300
250
200
150
100
50
0
2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035
Reference Case
Upper Bound
Local Growth & Constricted Supply
Global Growth & Carbon Step Change
Global Economic Stagnation
Lower Bound

Results:

Industrial Gas Demand

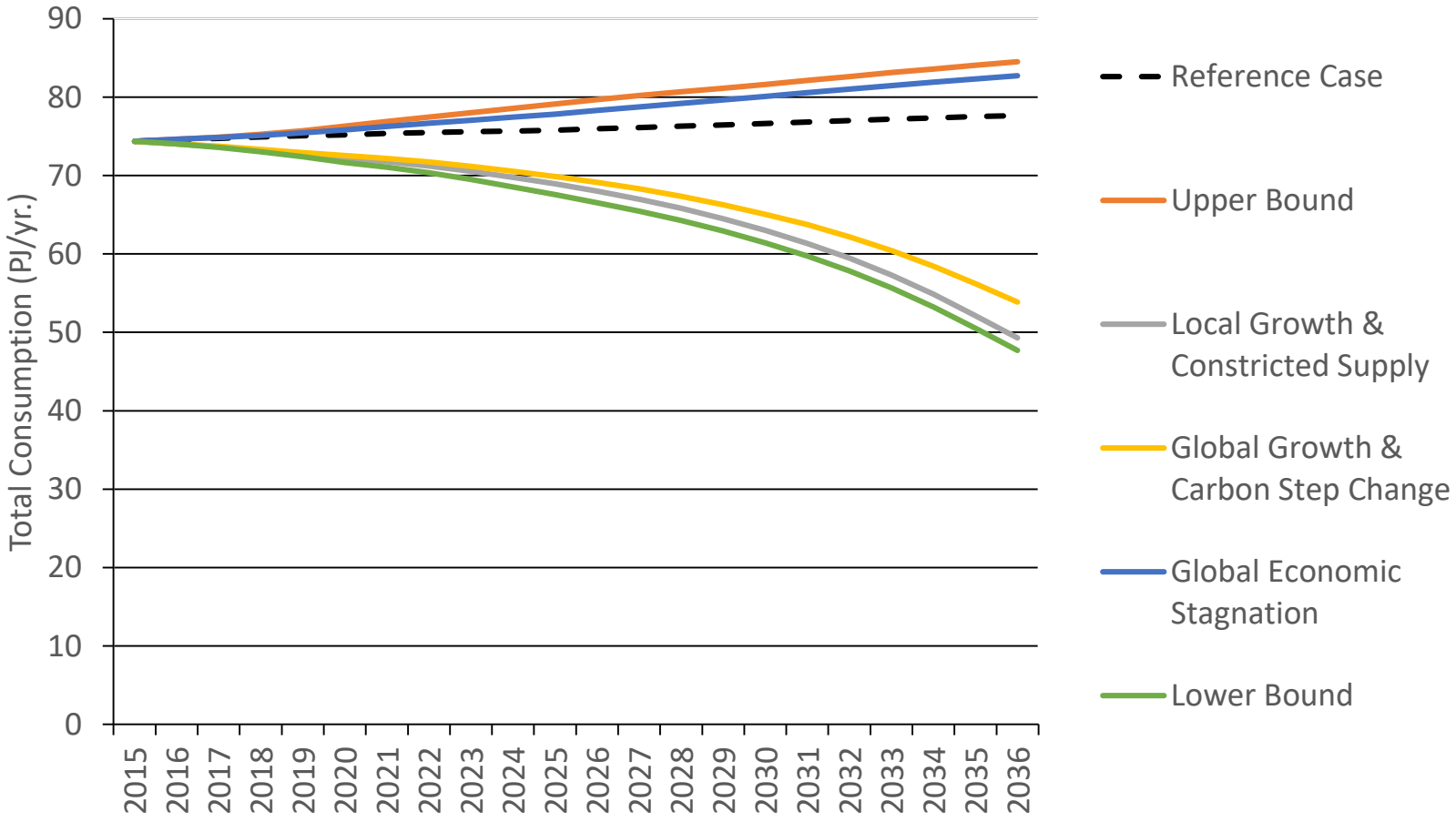


Results:


Commercial Gas Demand
Total Consumption (PJ/yr.)
90
80
70
60
50
40
30
20
10
0
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
Reference Case
Upper Bound
Local Growth & Constricted Supply
Global Growth & Carbon Step Change
Global Economic Stagnation
Lower Bound

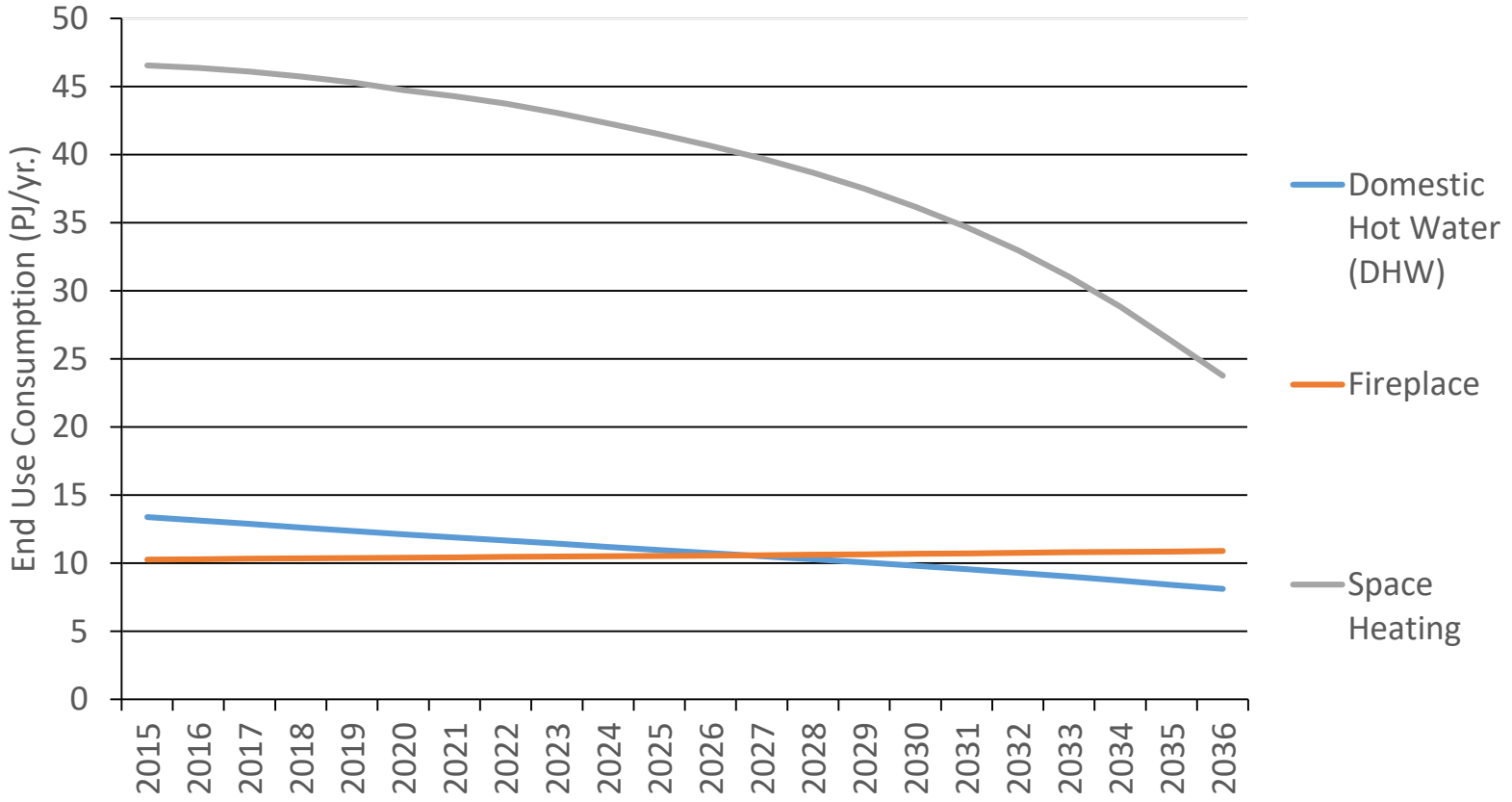
Results:

Residential Gas Demand



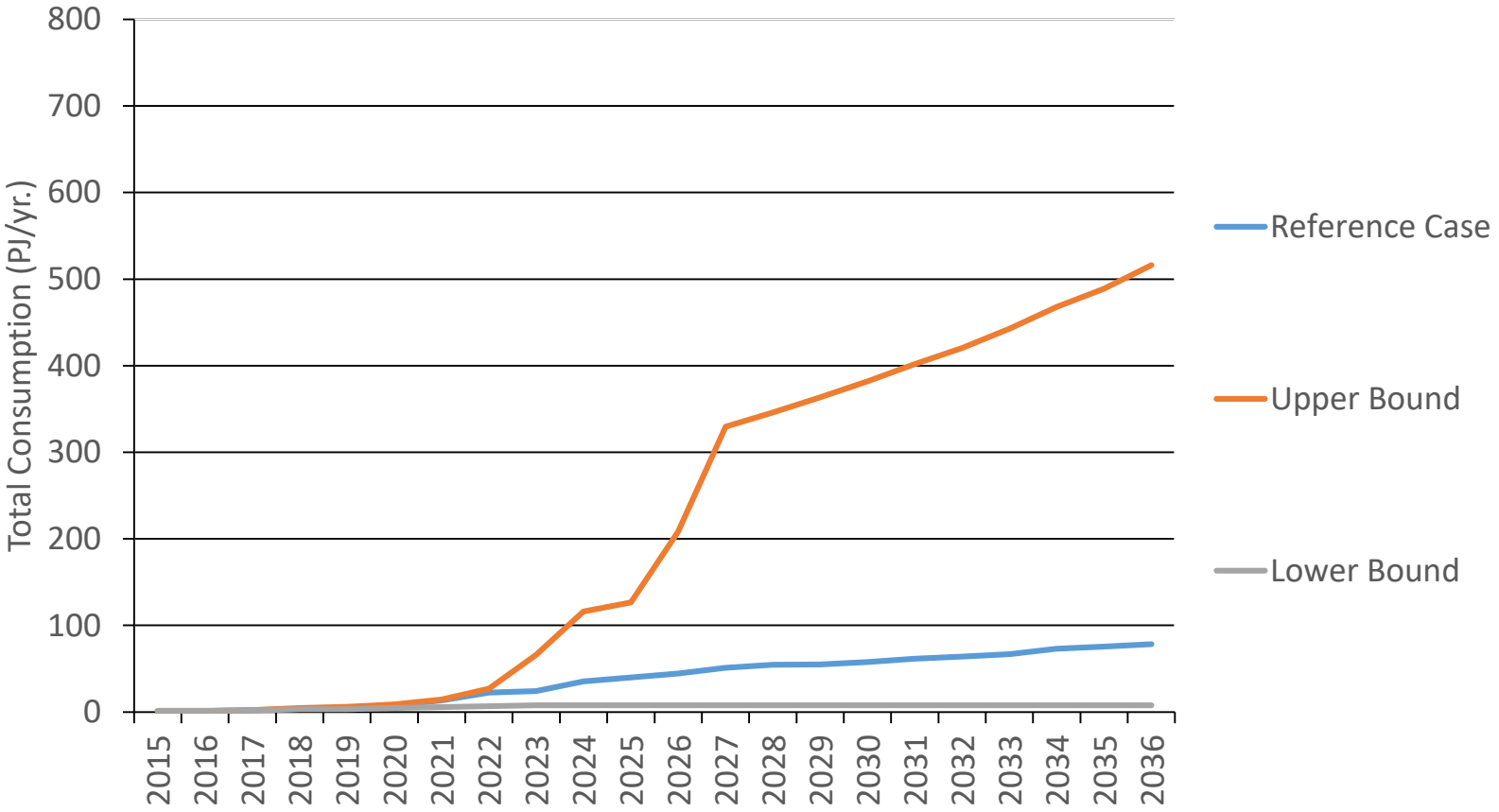
Results:

Residential Major End Uses (Lower Bound)



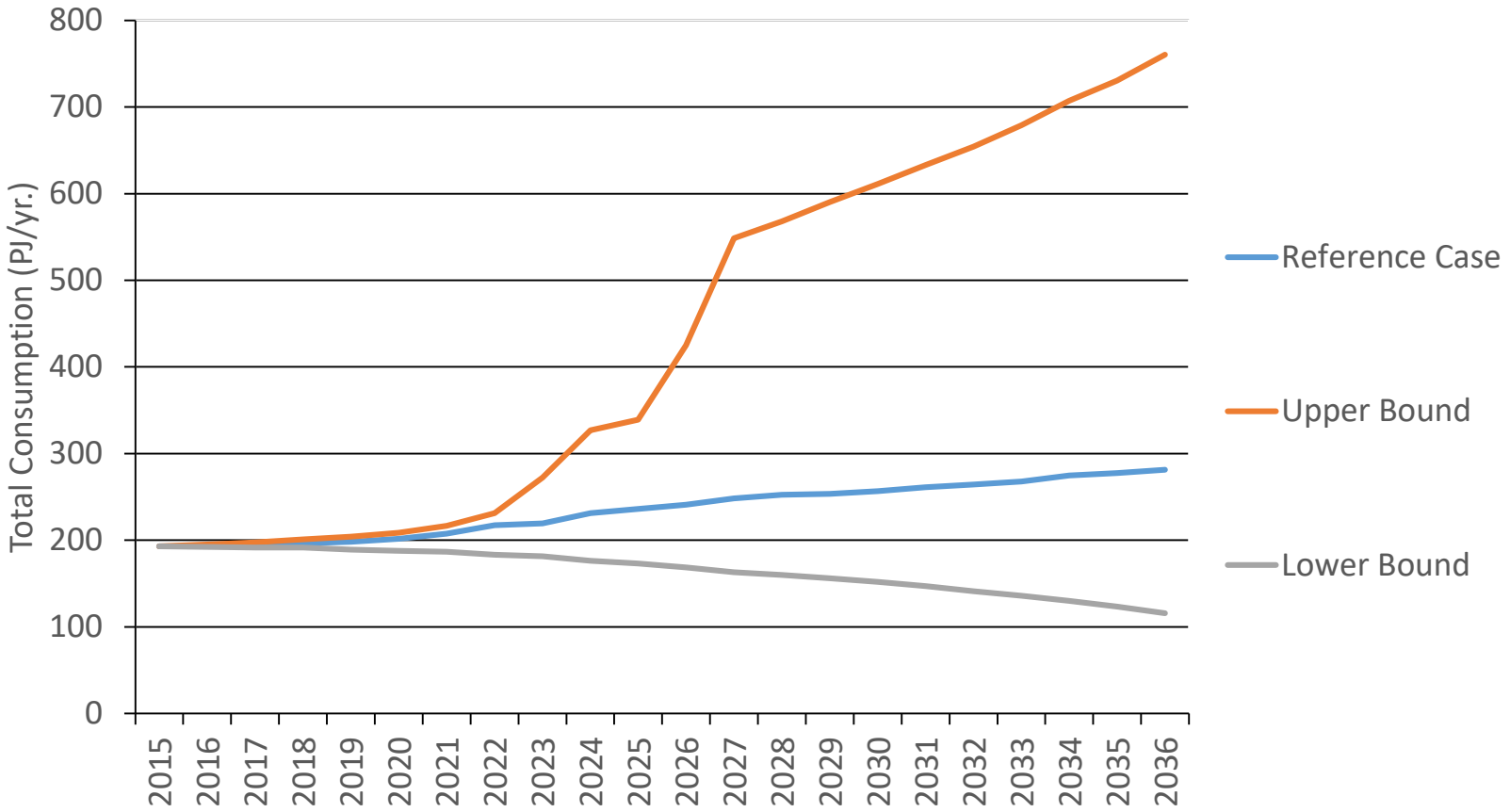
Results:

Natural Gas Transportation (includes ships!)



Results:

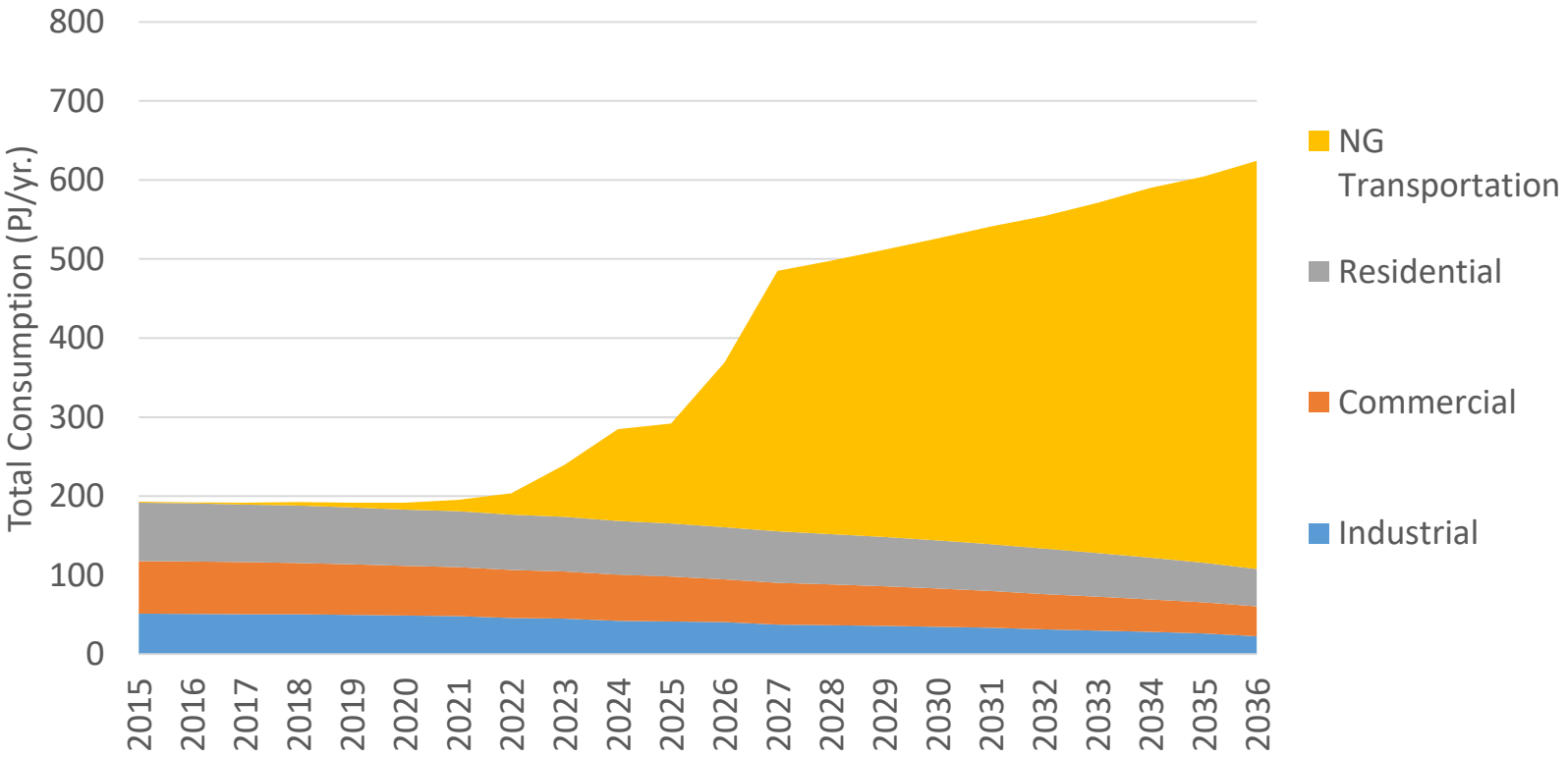
Total Gas Demand (inc. NGT)



Results:

What if:

Traditional Usage Declines and NGT Expands?



Conclusion

- Energy end use forecasting can improve utility long term planning
- Building archetype modeling can make energy end use input assumptions more accurate
- Multi-scenario modeling can manage uncertainty from input assumptions
- Risk management is improved
- Exploration of “what if” and “goal seeking” scenarios is easier

Questions?

David Shipley

shipley@posteritygroup.ca