The University of Texas at Austin
Civil, Architectural and Environmental Engineering
Cockrell School of Engineering

INTELLIGENT ENVIRONMENTS LABORATORY

Smart Decarbonization of the Built Environment in the Nexus of Climate Change, Population Growth and Technology Adoption

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- Cale Reeves, LBJ School of Public Affairs

The University of Texas at Austin
Cockrell School of Engineering

TEXAS Architecture
The University of Texas at Austin
School of Architecture

TEXAS LBJ School
The University of Texas at Austin
Lyndon B. Johnson School of Public Affairs

30%

of US greenhouse gas emissions stem from **buildings**

mostly for **heating** and **cooling**

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Paper

https://arxiv.org/abs/2202.07458

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“Cities are at the center of climate action”

IEA, *Empowering Cities for a Net Zero Future*, 2021

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"Cities are at the center of climate action"

IEA, *Empowering Cities for a Net Zero Future*, 2021

Yet very few tools exist to project expected emissions for combinations of decarbonization scenarios

→ **IMPACT Pathways**

IMPACT: **I**NTEGRATED **M**ULTI-DOMAIN EMISSION **PA**THWAYS FOR **C**ITIES UNDER LAND-USE POLICY, **T**ECHNOLOGY ADOPTION, CLIMATE CHANGE AND GRID DECARBONIZATION

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Decarbonization of the built environment

- ✓Electrification of end use (heating/cooling)
- ✓High-efficiency HVAC (& lighting)
- ✓Local PV generation
- ✓Grid decarbonization

(Leibowicz et al, 2018)

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How to incentivize?

How fast?

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(Leibowicz et al, 2018)

How to incentivize?

How fast?

How does climate change impact demand?

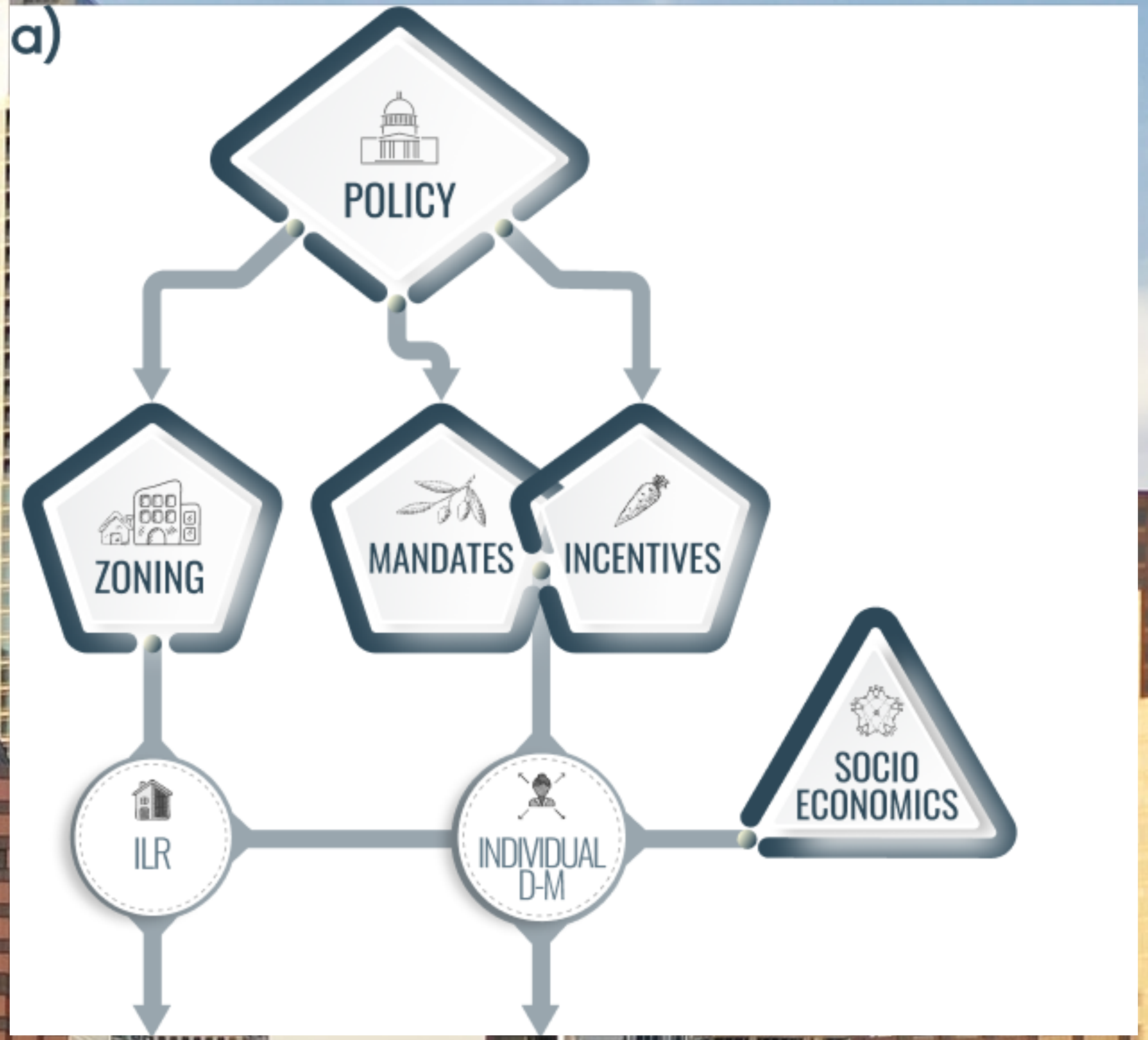
How does city growth impact demand?

Goal:

- **create model to capture interactions**
- **investigate trade-offs & synergies**
- **ex: tech adoption vs urban development**

Model implementation in Austin, TX

- 3 neighborhoods (Brentwood, South Manchaca and Montopolis)
- Emission pathways until 2100 in decades



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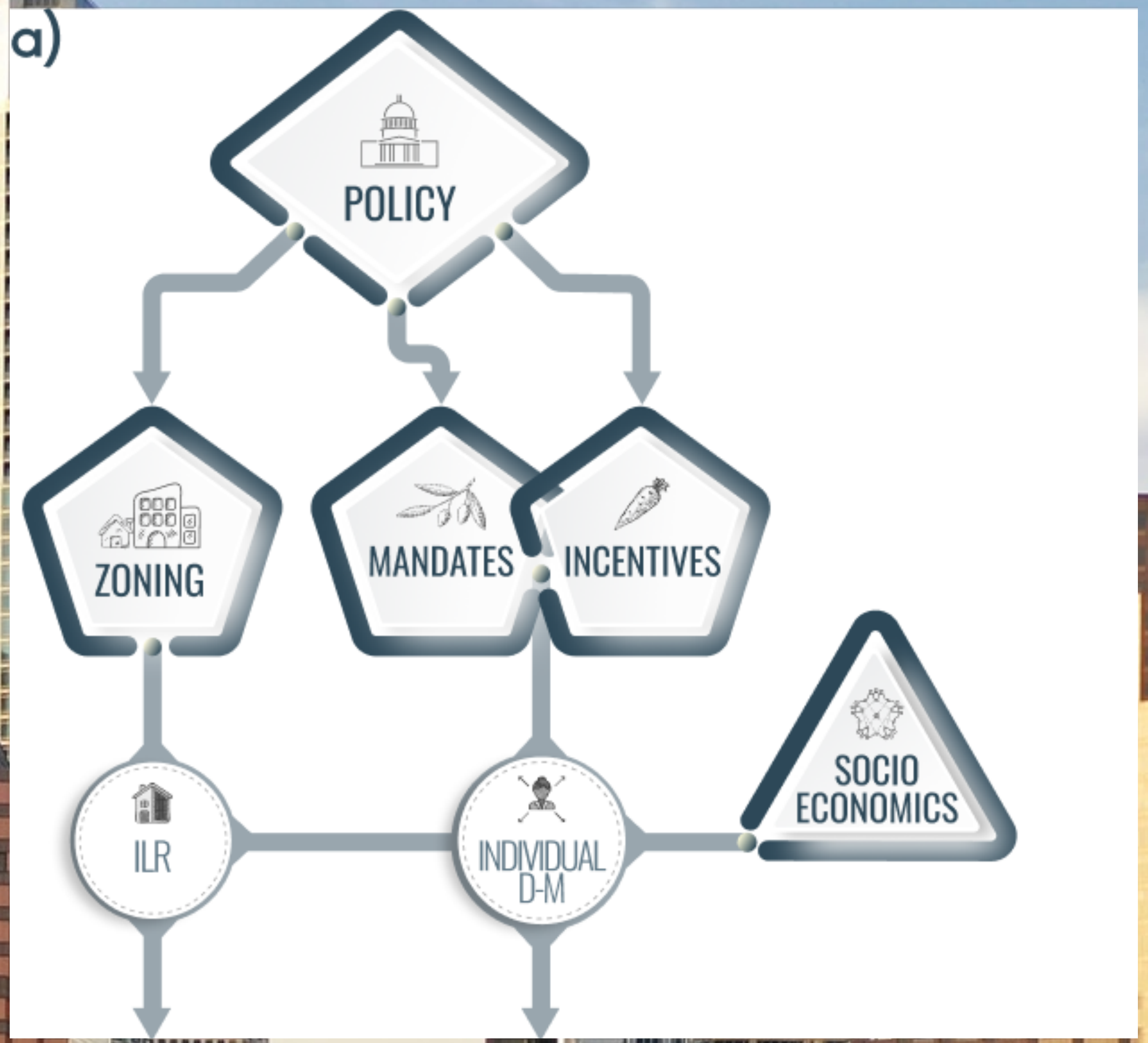
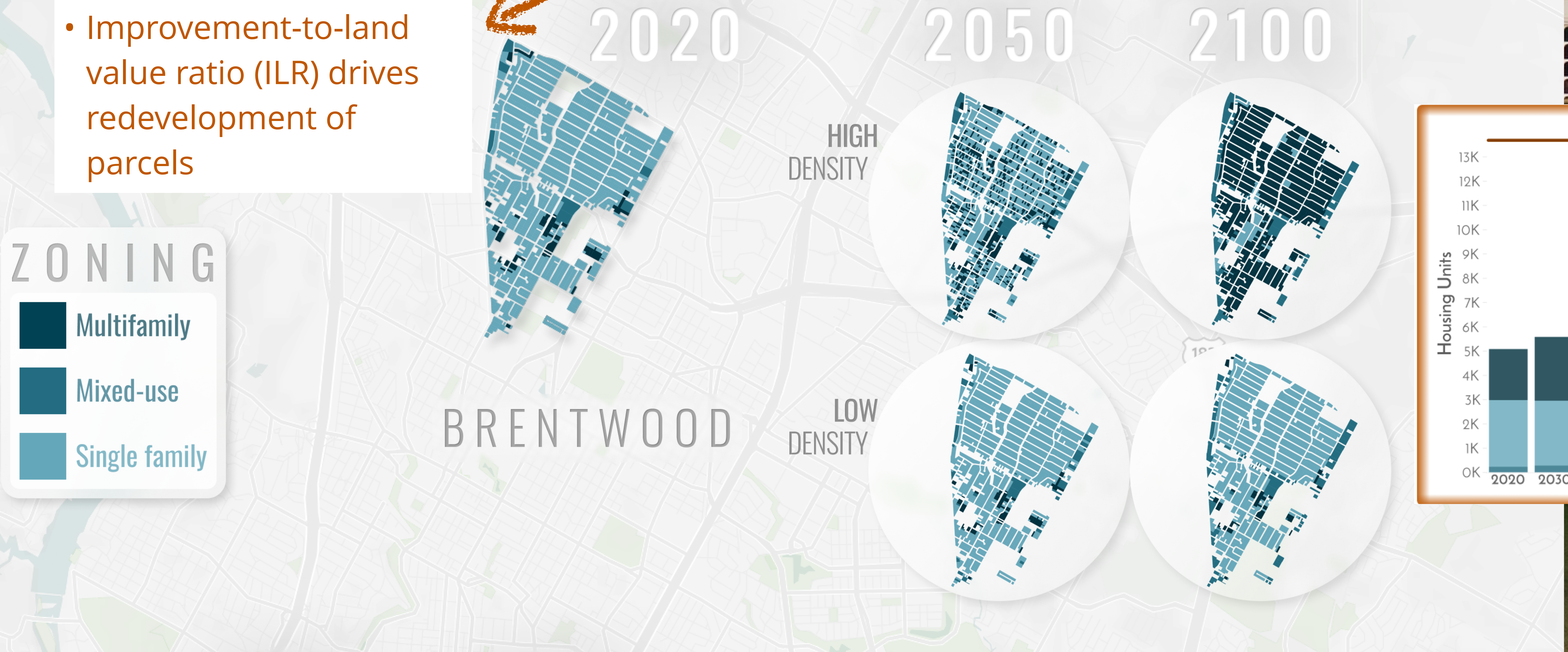
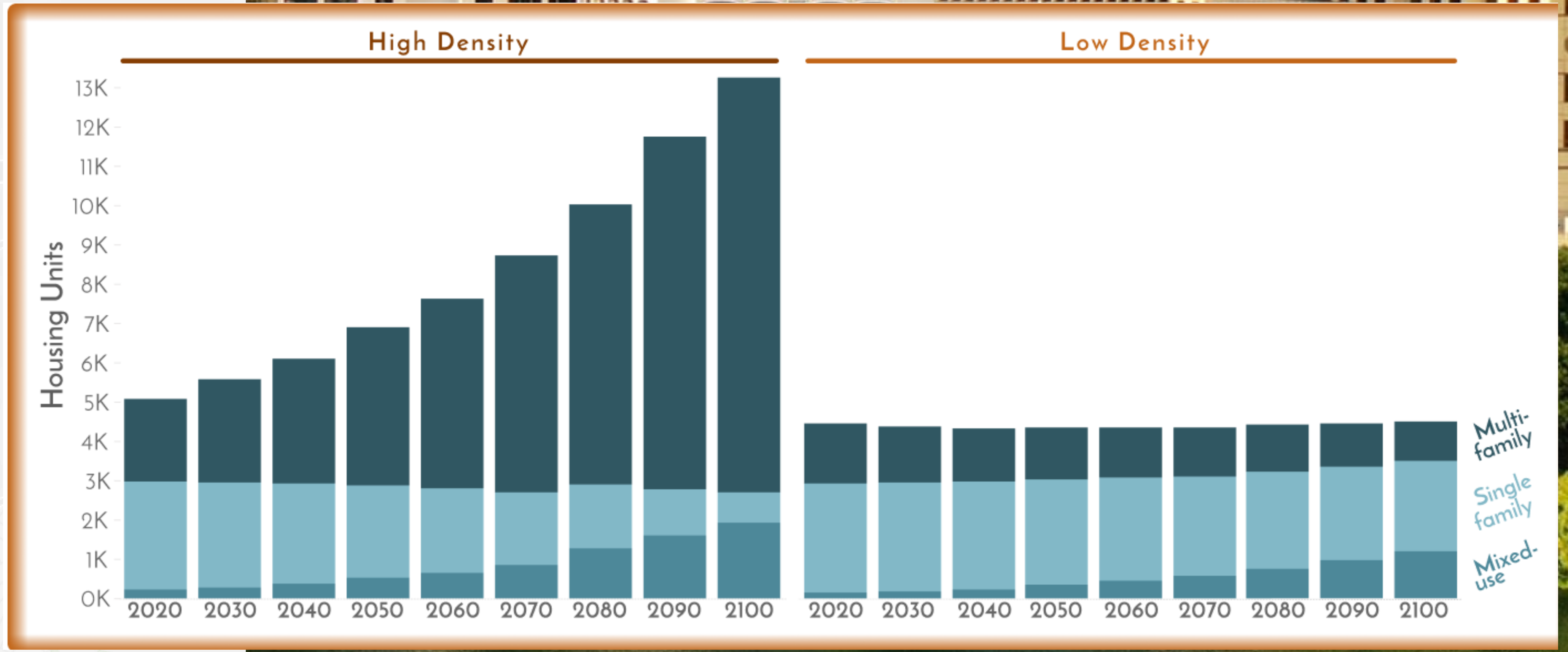


- Low and high density scenarios created using Envision Tomorrow

- Improvement-to-land value ratio (ILR) drives redevelopment of parcels





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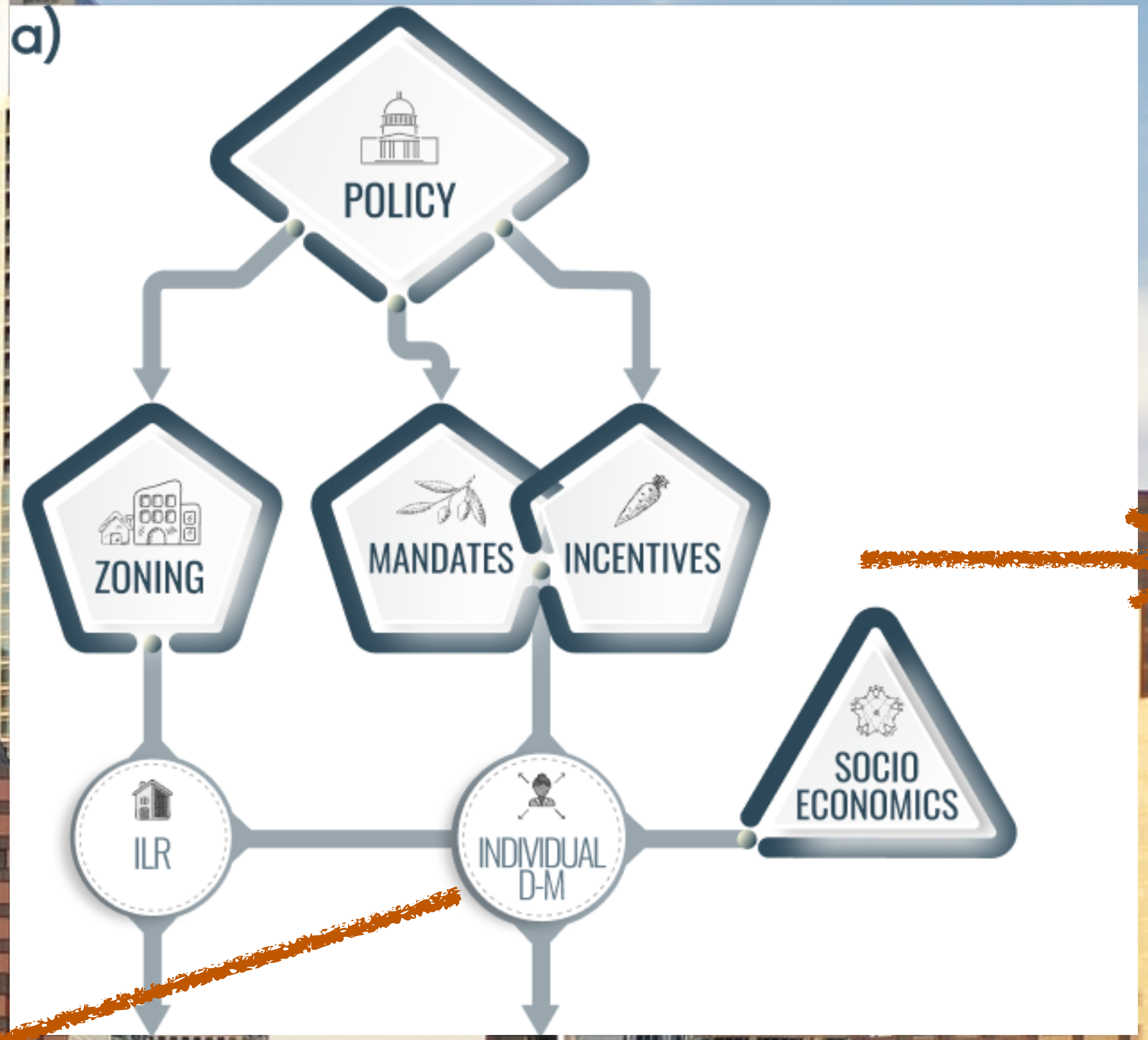

	POLICY		ECONOMICS
	Incentives	Mandates	Prices
Supportive	✓	✓	decreasing
Neutral	—	—	constant

Agent based model in each residence decides whether or not to adopt

- high efficiency HVAC
- PV & storage
- smart thermostat

Based on two incentive/mandate scenarios and socio economics

Model developed and validated with survey in Austin, TX

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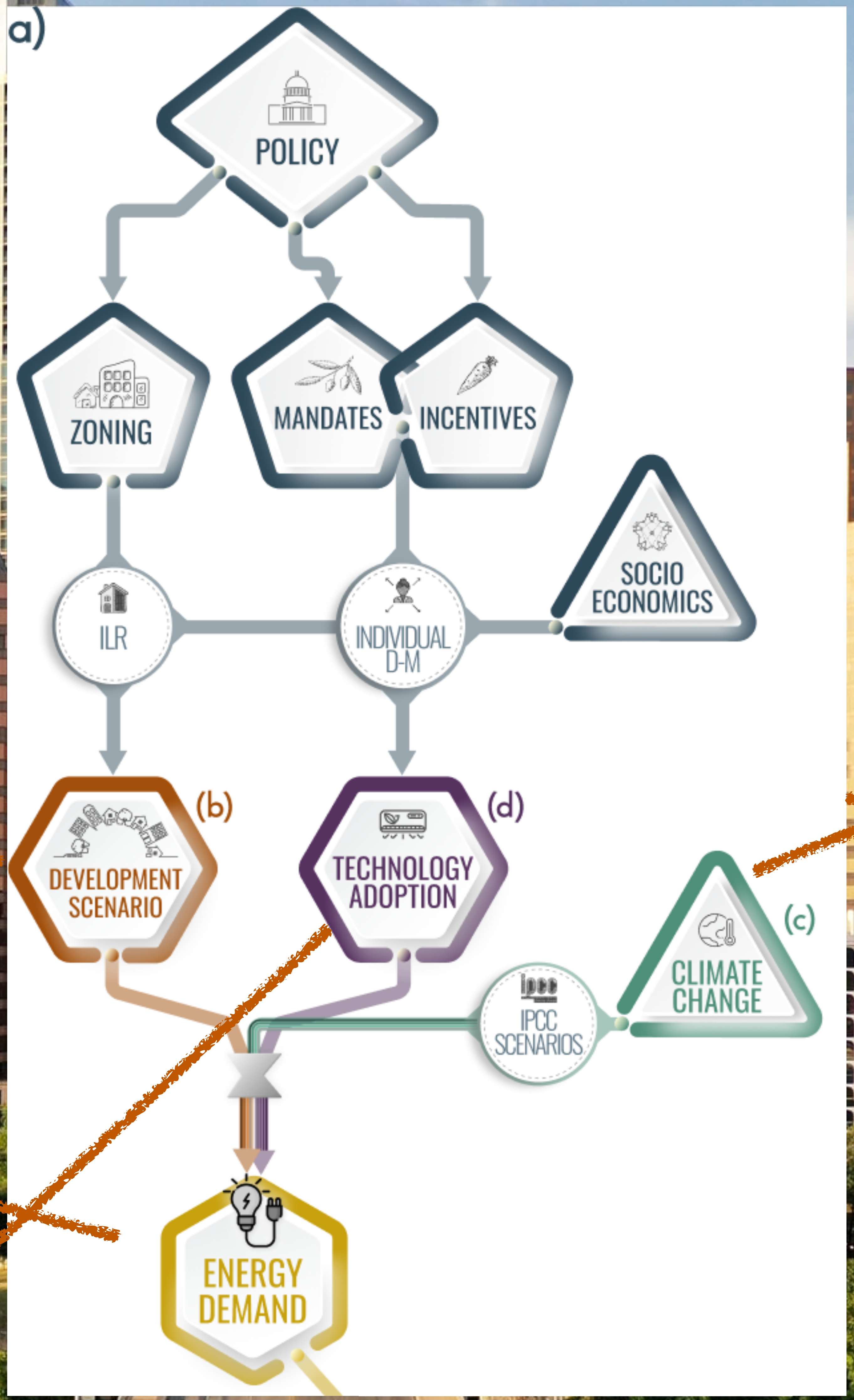
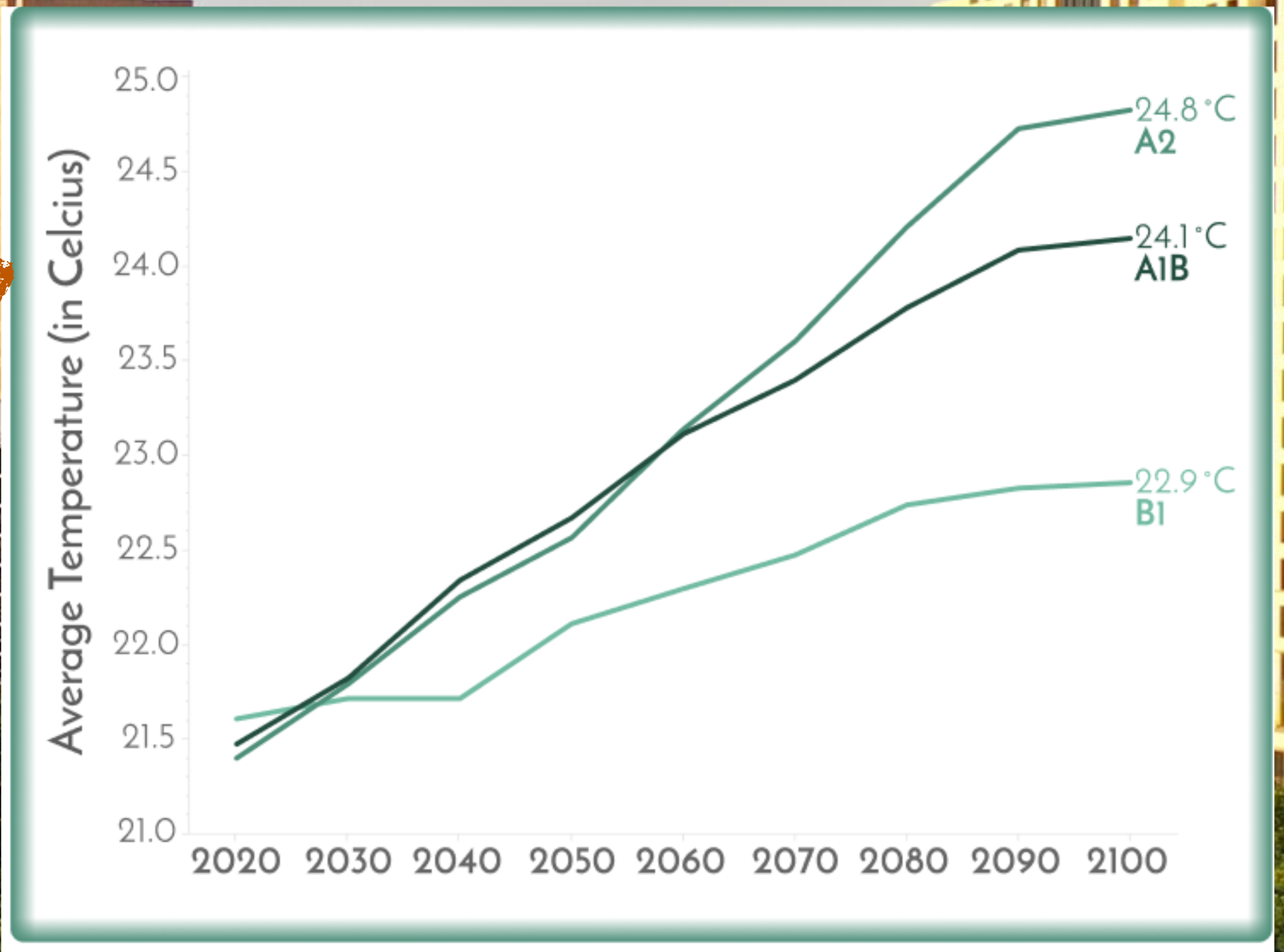
Model implementation in Austin, TX

- Parcels are redeveloped according to scenarios
- Each building is modeled and simulated to determine annual energy demand under climate change
- Energy demand is reduced accordingly for buildings that adopted technologies





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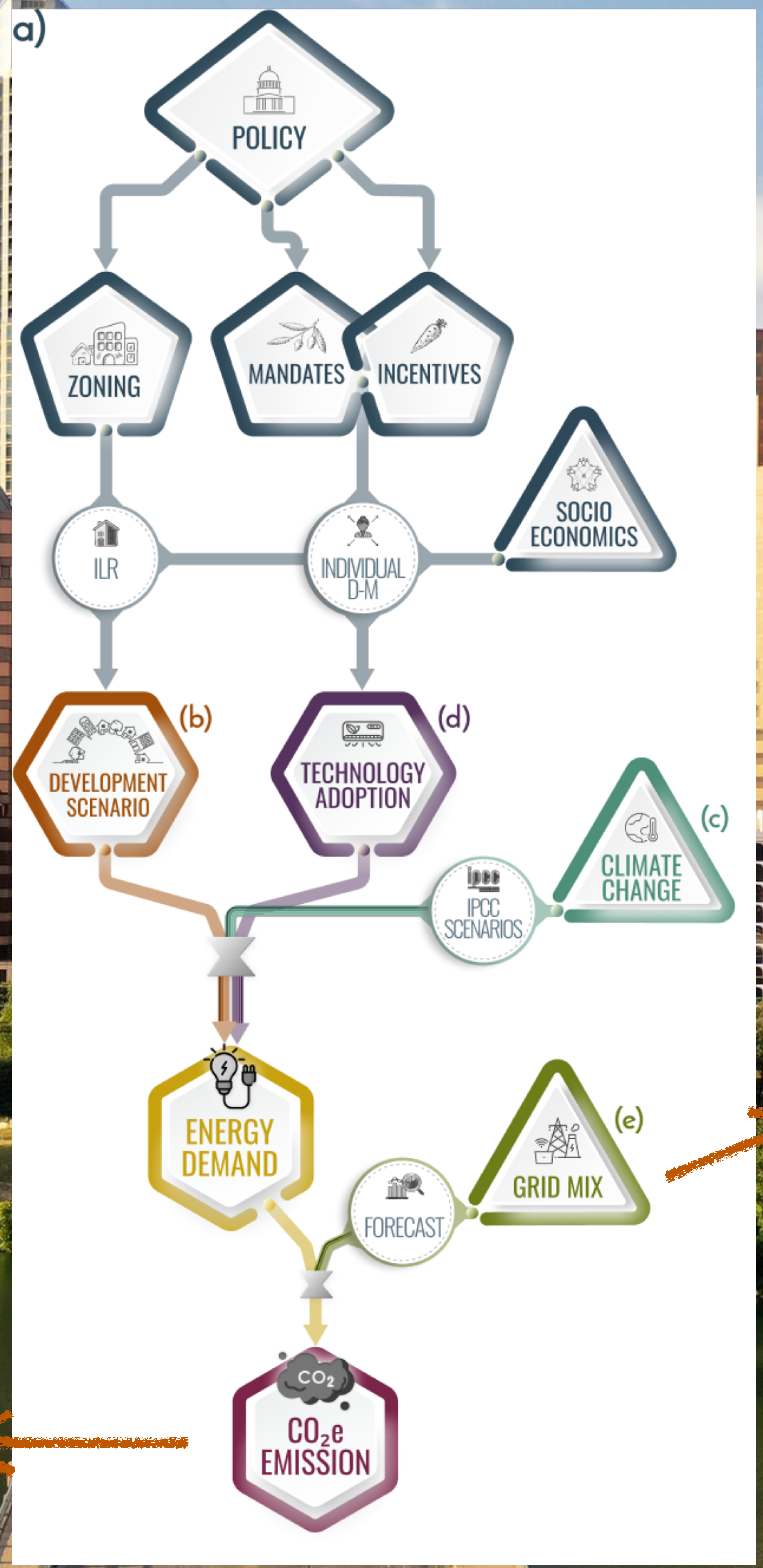
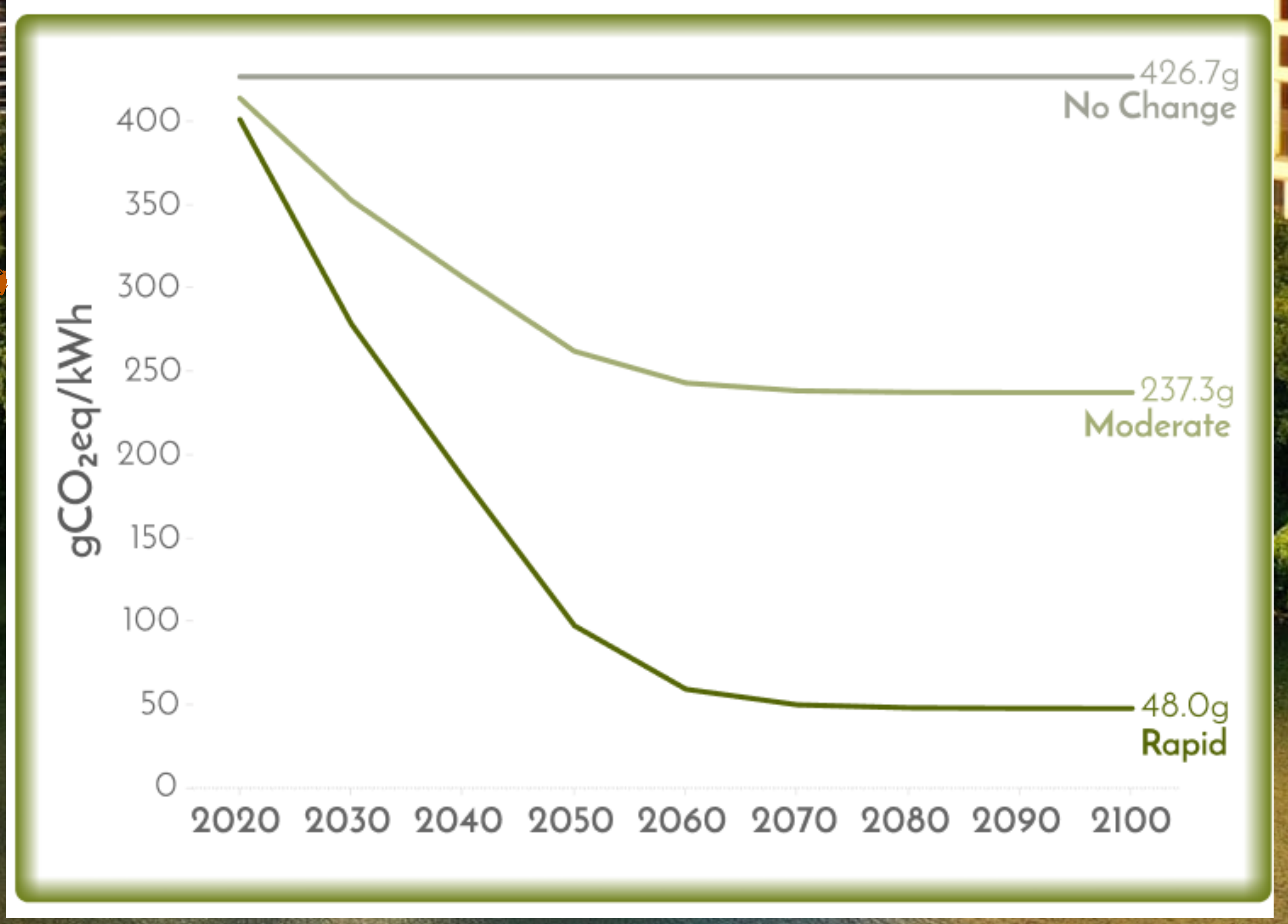


Emissions estimated assuming
- energy demand is met fully electrically (strong assumption)
- based on grid decarbonization scenarios



Summary

- 2 urban development scenarios
- 2 incentive/mandates scenarios
- 3 climate change scenarios
- 3 grid decarbonization scenarios
- 3 neighborhoods

loads of data to explore

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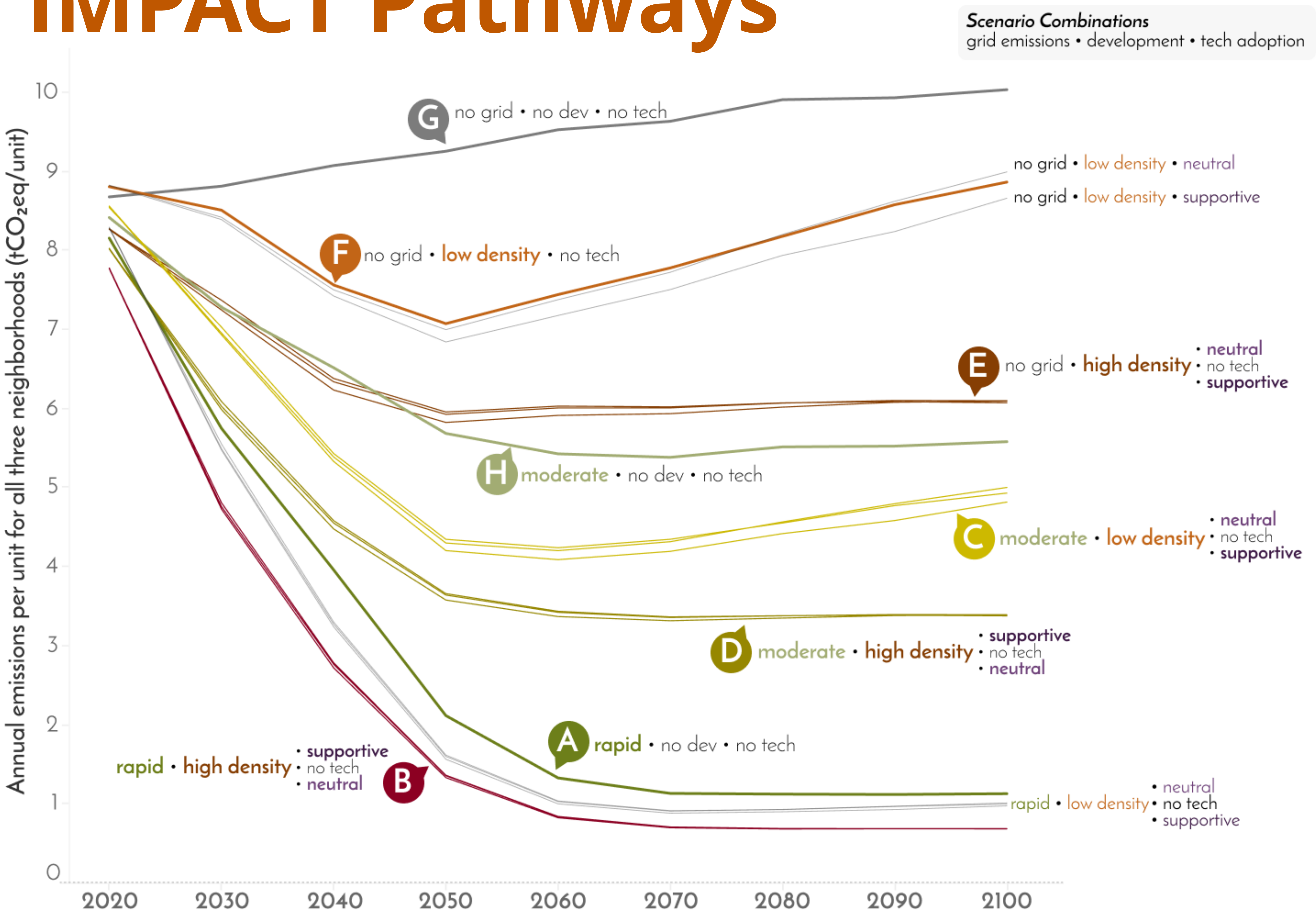
IMPACT Pathways

for A1B climate scenario (+1.5C by 2050, +2.5C by 2100)



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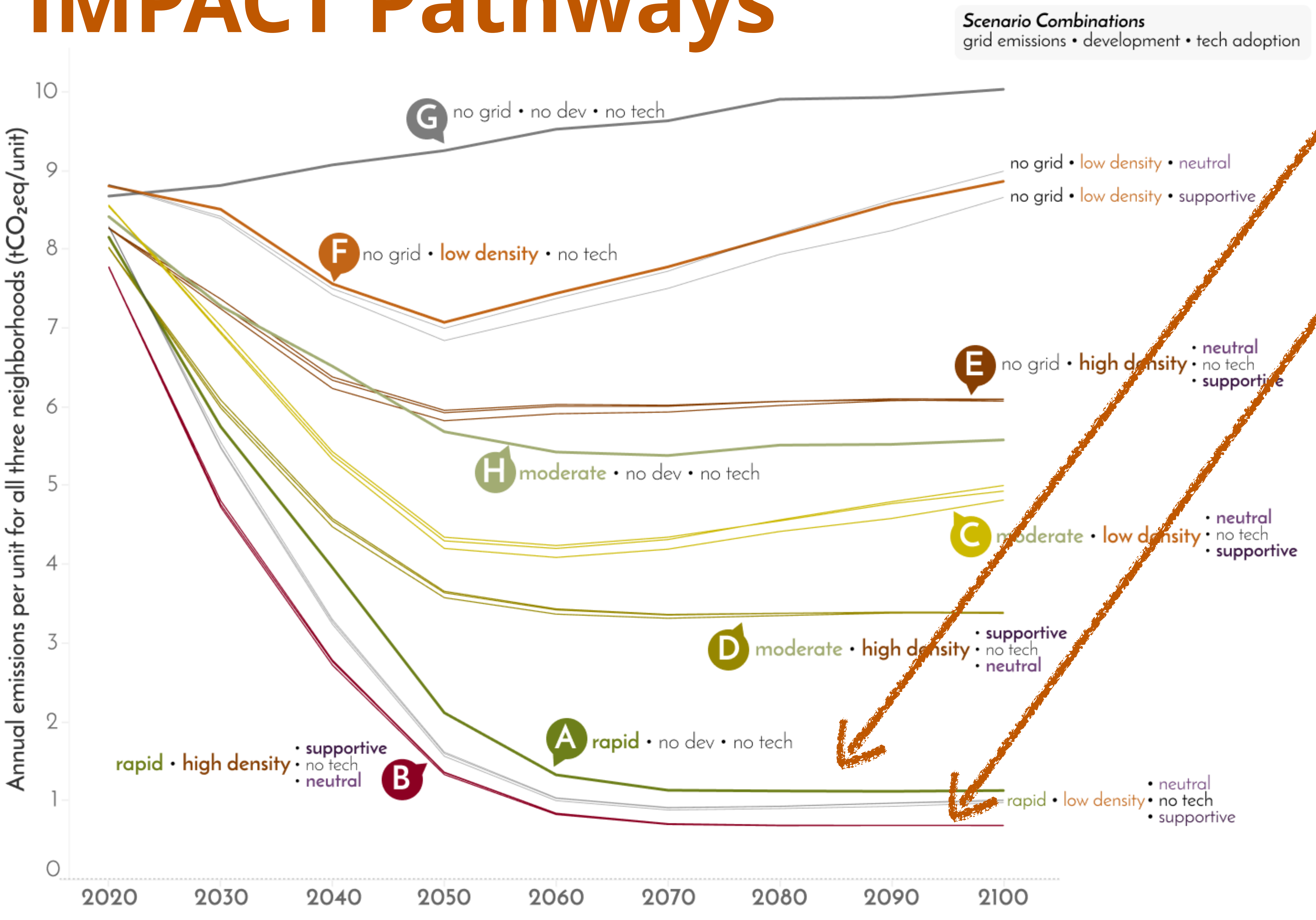
IMPACT Pathways



A. Rapid grid decarbonization results in the fastest emission reductions.

B. Emission reductions are amplified by densification.

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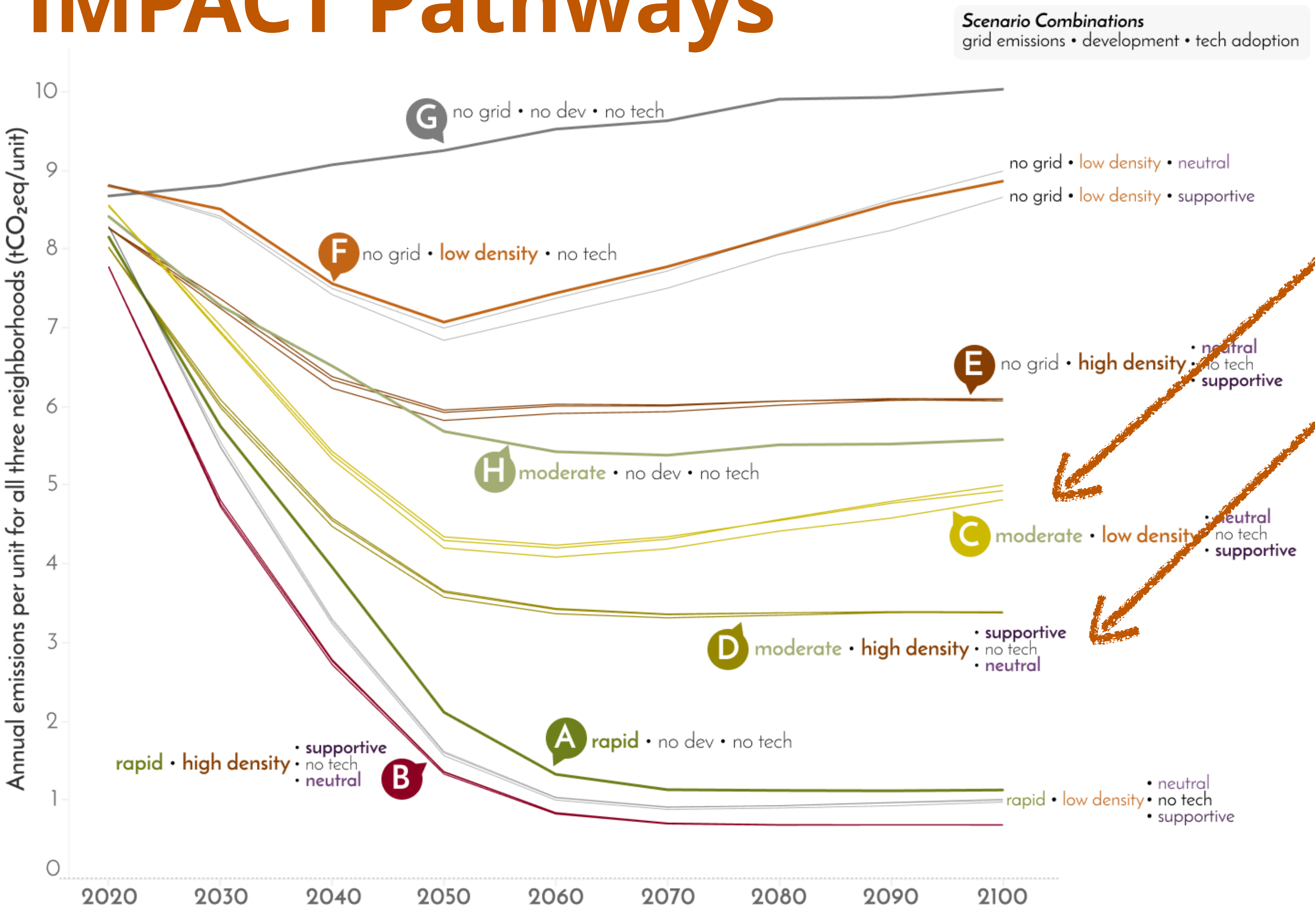
IMPACT Pathways



A. Rapid grid decarbonization results in the fastest emission reductions.

B. Emission reductions are amplified by densification.

C. For moderate grid decarbonization, low-density development shows rebound of emissions after 2060, while

D. The high-density development does not show rebound.

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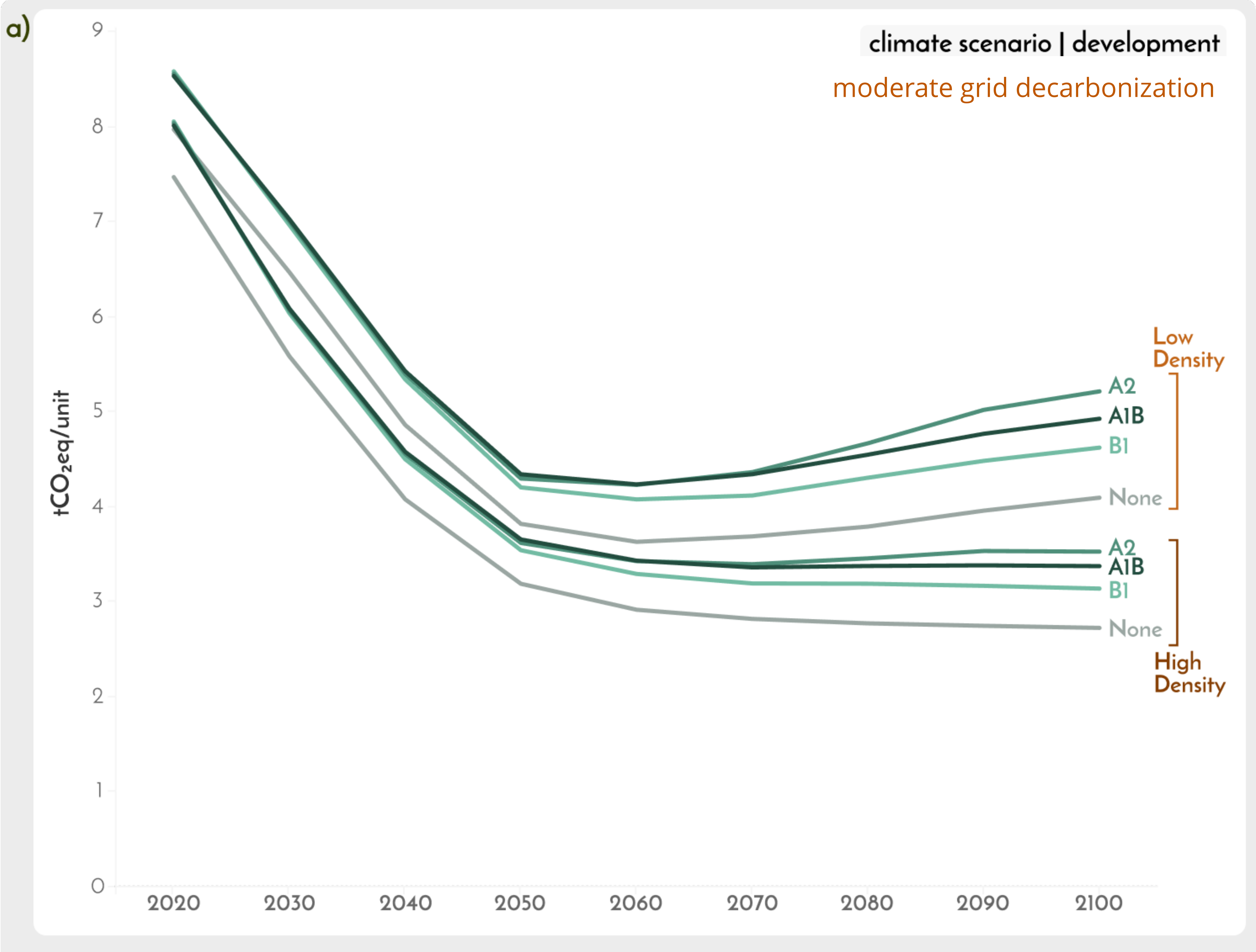
Climate Change & Premium for Sprawl



Climate Change amplifies difference between low and high density developments

→ Premium for Sprawl

Paper

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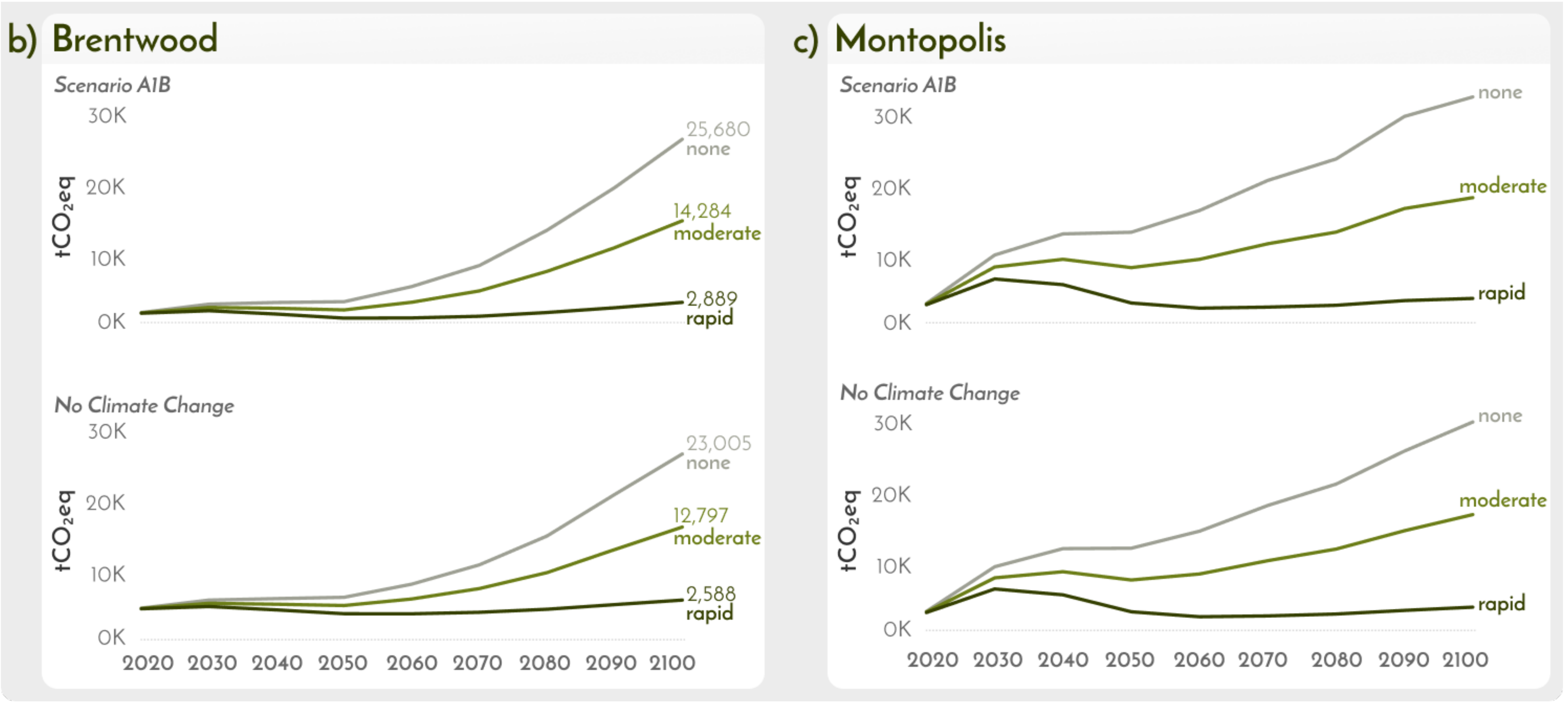
Climate Change & Premium for Sprawl

Premium for Sprawl = Emissions (High Density) - Emissions (Low density)

(assuming the same number of residences)

grid decarbonization scenarios



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ZOLTAN NAGY[1,*], JULIANA FELKNER[2], ARIANE L. BECK[3], D. CALE REEVES[3,5], STEVEN RICHTER[2], VIVEK SHASTRY[3], ELI RAMTHUN[1,6], EDWARD MBATA[1,7], STEPHEN ZIGMUND[2], BENJAMIN MARSHALL[1], LINNEA MARKS[4], VIANEY RUEDA[3], JASMINE TRIPLETT[3], SARAH DOMEDEAD[3], JOSE VAZQUEZ-CANTELI[1], AND VARUN RAI[3]

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[6] DNV, NORWAY
[7] EPIC SYSTEMS CORPORATION, VERONA, WI, USA

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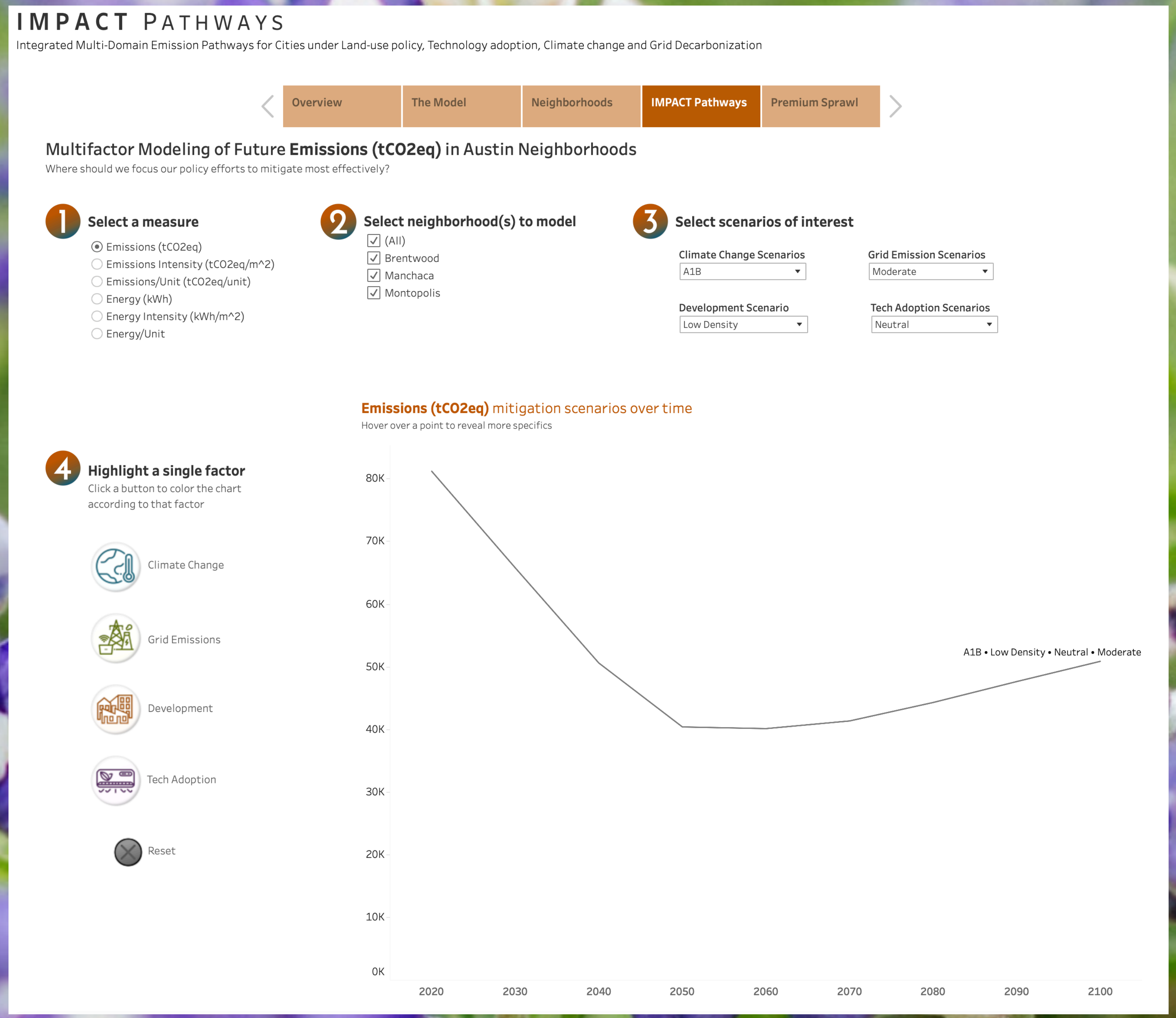
Conclusion

- ➡ IMPACT Pathways demonstrate substantial impact of zoning policy and housing on emission reductions: *Premium for Sprawl*. Technology adoption is negligible.
- ➡ *Rebound*: Short term emission reductions can be overturned in the longer term
- ➡ Demand variation due to climate change must be considered in emission scenarios
- ➡ IMPACT Pathways can be further integrated with other domains, e.g., transportation emissions, embodied carbon, EV adoption, or demand response.



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