How does IRA compare to an optimal deep decarbonization pathway in the electricity sector?

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Prepared for:

Breakthrough Energy Ventures

Prepared by:

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Background on Evolved Energy Research

- Evolved addresses key policy and strategy questions raised by a transformation of our energy system to meet greenhouse gas emission goals

NGOs

NRDC, TNC, SDSN, GridLab, Sierra Club, CETI, OCT, UCS, EDF, CATF, BPC, Third Way, RMI, and others

State & Local Energy Offices

Massachusetts, Washington, San Diego, and New Jersey

Utilities

PGE, DTE, Hydro Quebec, and others

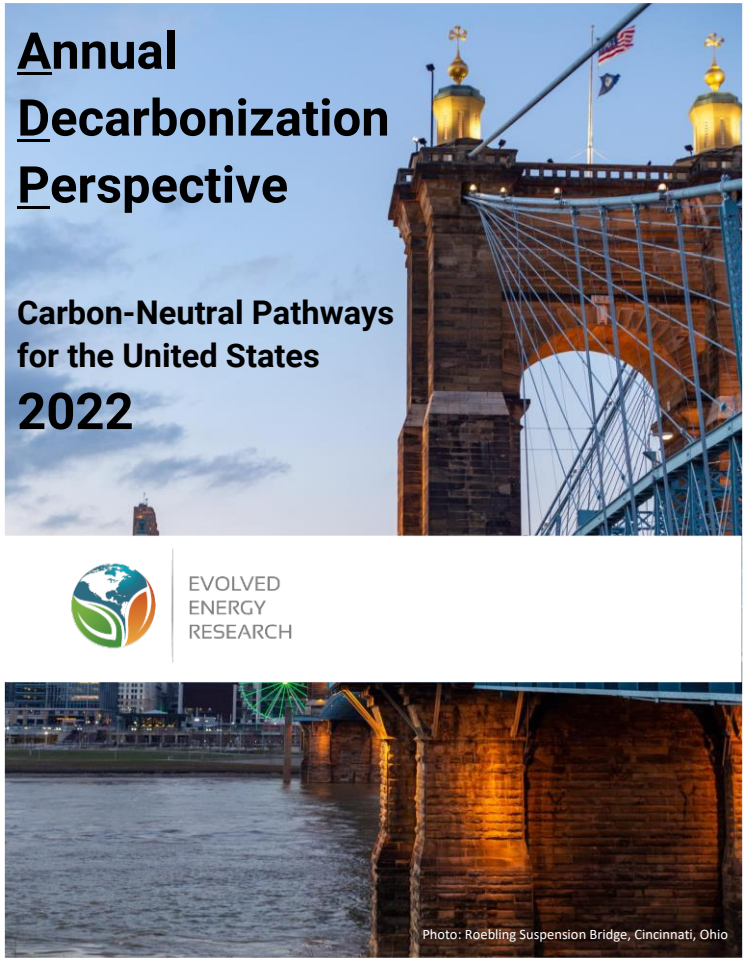
Others

Princeton University, University of Queensland, Breakthrough Energy, Inter-American Development Bank, DOE, NREL, UVA

Annual Decarbonization Perspective

- Follow up to Williams et al., Carbon Neutral Pathways for the United States, *AGU Advances*, 2021 and earlier work of DDPP
- Funded by Breakthrough Energy Foundation to produce annual updates with new data, scenarios, and modeling capabilities
  - **Goal 1:** Produce the granular modeling necessary to create actionable emissions plans for the United States
  - **Goal 2:** Develop public datasets for other researchers exploring energy system questions
  - **Goal 3:** Reinforce modeling best practices
  - **Goal 4:** Encourage institutionalization of decarbonization pathways modeling by U.S. government, a la *Annual Energy Outlook*

https://www.evolved.energy/post/adp2022



Rapid Energy Policy Evaluation and Analysis Toolkit

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- The **REPEAT Project** provides regular, timely, and independent environmental and economic evaluation of federal energy and climate policies
  - Offers a detailed look at the US's evolving energy and climate policy environment and progress toward net-zero GHG.
- **Approach:** refines the Net-Zero America methods, coupling detailed macro-energy system optimization models with geospatial planning and analysis tools.
- **Goal:** provide independent, timely, and credible analysis for stakeholders, decision-makers, and the media.
- **Funding:** funding for the REPEAT Project was provided by a grant from the Hewlett Foundation.

REPEAT Team

PRINCETON UNIVERSITY
ZERO LAB

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For additional details see https://repeatproject.org/

Net US GHG emissions including land carbon sinks

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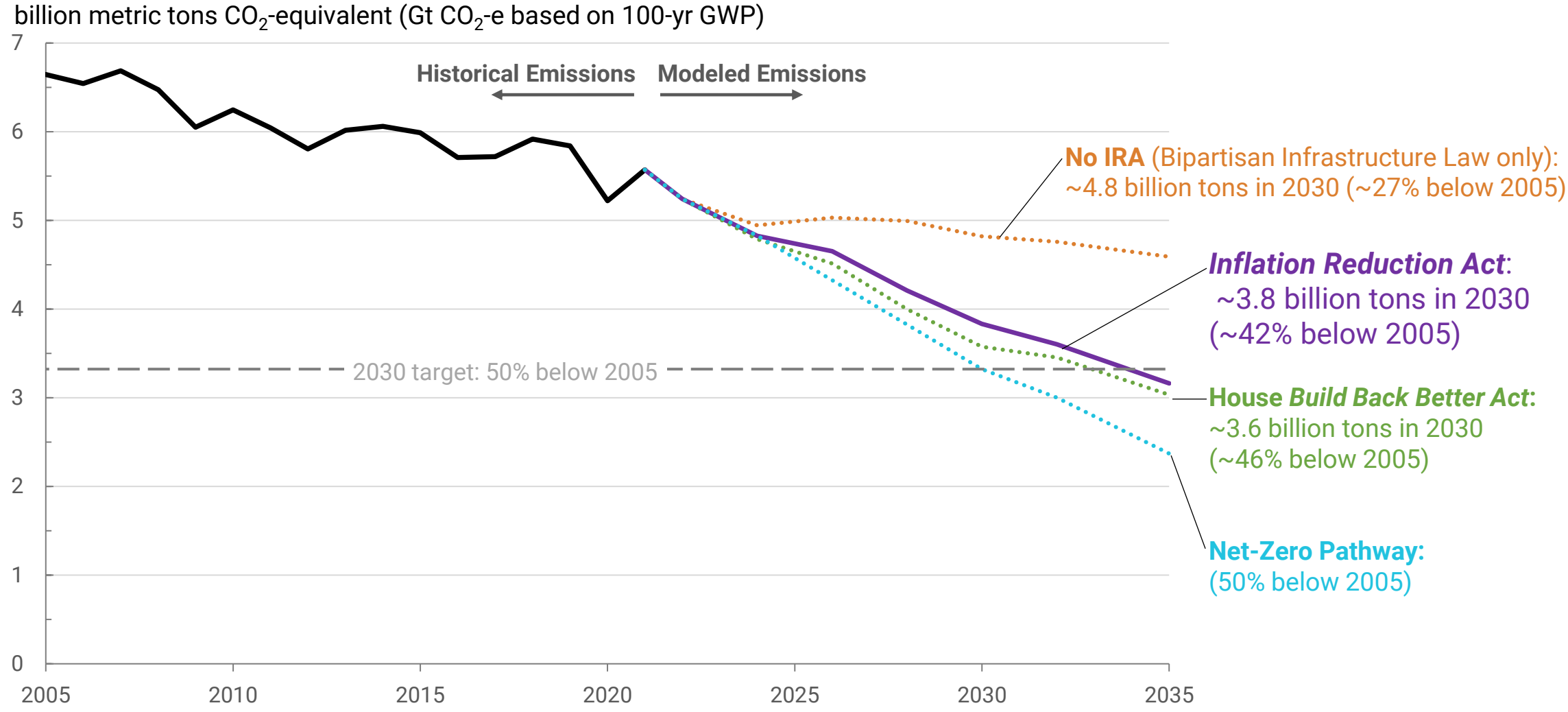

https://repeatproject.org/

ADP Release and the Inflation Reduction Act

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- ADP was released just prior to the passage of the Inflation Reduction Act (IRA) in August and so did not contain a representation of the IRA in the modeling
- We are interested in the question of how the IRA compares with our optimal net-zero pathway develop through the ADP and what lessons we can learn from those differences
- Key Questions:
  - What areas of deep decarbonization are supported by the IRA? Where are the gaps?
  - What are the opportunities for regulatory policy, state policy, and technology progress to address those gaps?
  - Does the relative weight of policy ambition in the IRA (clean electricity, hydrogen, carbon capture, etc.) change the optimal decarbonization strategy?

Analytical Plan

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- Run three scenarios with consistent input assumptions
  - Annual Decarbonization Perspective's **Central** scenario* that contains no IRA provisions
  - An **IRA** scenario derived from our work with the Princeton REPEAT project
  - An **IRA + Central** scenario that represents IRA provisions in addition to the economy-wide targets in our **Central scenario**

**Results vary from August version based primarily on near-term renewable build rate constraints*

Scenario Descriptions

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Scenario	Description
IRA	This is EER's representation of IRA provisions including demand-side programs, non-energy reductions, land sink contributions, and tax credits.
Central	This is the least-cost pathway for achieving net-zero greenhouse gas emissions by 2050 in the U.S. It is economy-wide and includes energy and industrial CO_2, non-CO_2 GHGs, and the land CO_2 sink. It is built using a high electrification demand-side case, and on the supply-side has the fewest constraints on technologies and resources available for decarbonization.
Central + IRA	This is the Central scenario that also includes a representation of the IRA, which accelerates and privileges certain technology deployments based on IRA provisions (tax credit etc.). It is the optimal pathway from the perspective of energy consumers given government programs and incentives.

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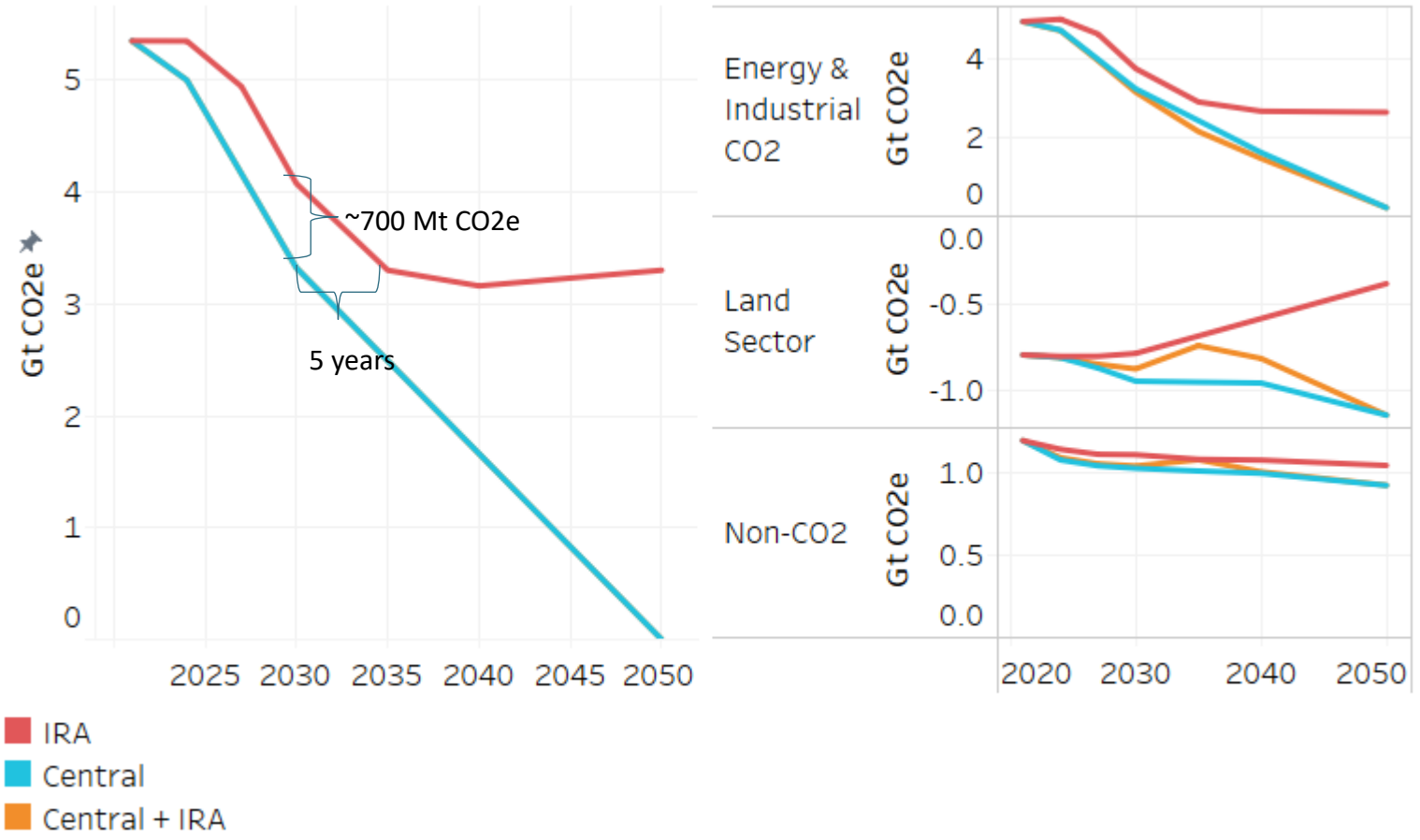
Results

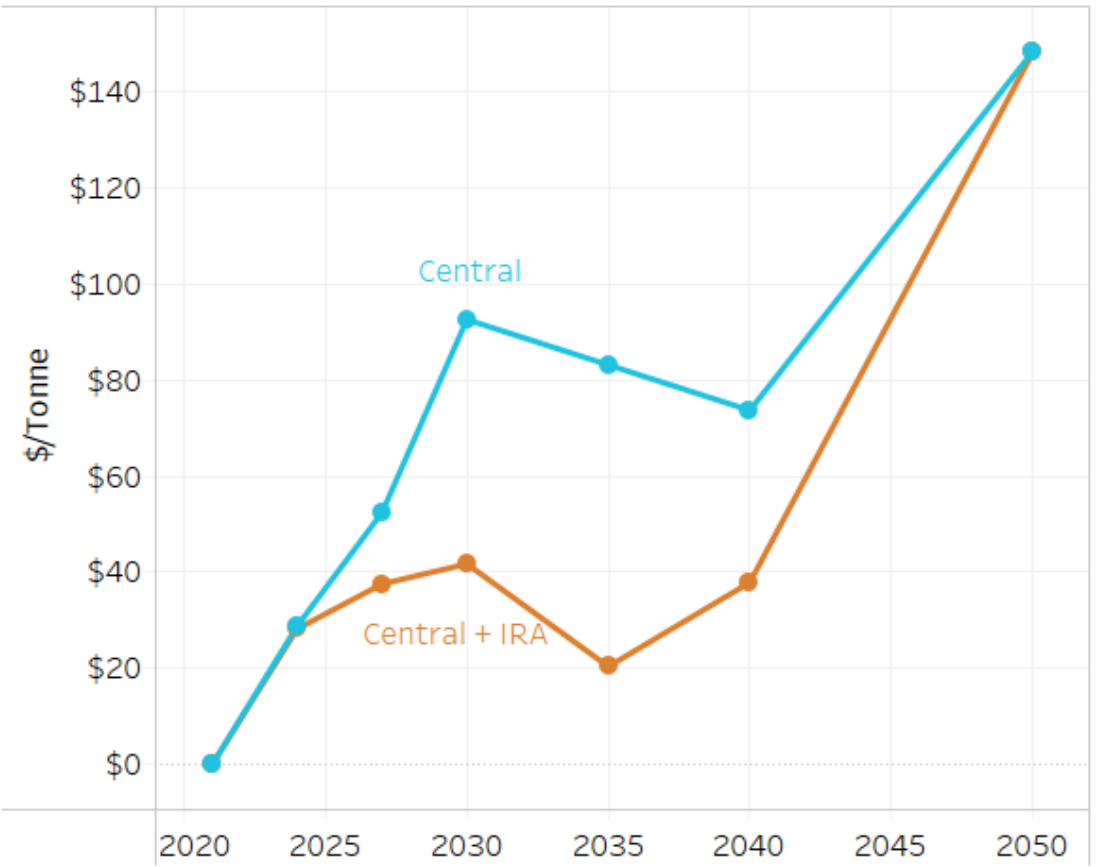
Emissions Trajectories

- ~ 700 Mt gap in 2030 (compared to 50% from 2005 reduction target) but this gap is closed over the next 5 years
- In the long-term, IRA scenario emissions asymptote at ~50% of 2005 levels
- **Central + IRA** scenario accelerates E&I reduction trajectory compared to **Central** scenario in order to take advantage of tax credits in energy, lowering the requirements for land-sector and non-co2 reductions



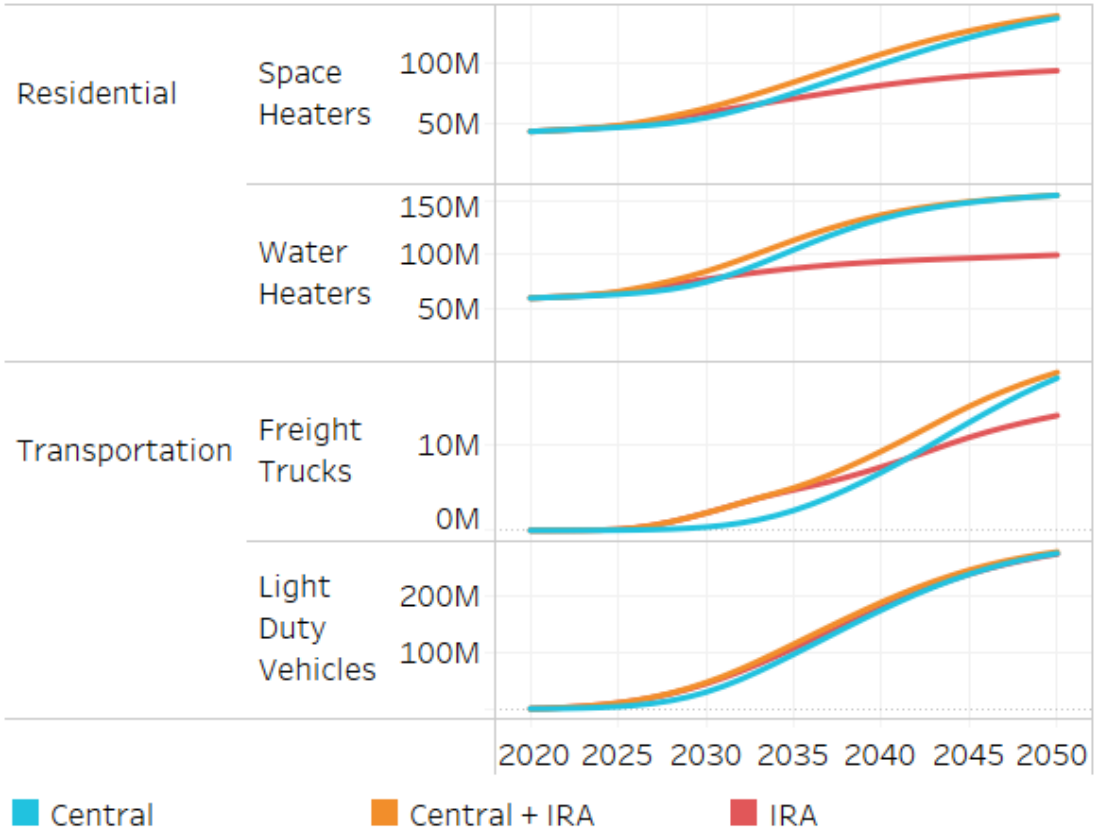
Emissions Price Trajectory

- IRA provides a $50/tonne subsidy in 2030 towards achieving a net-zero trajectory ($92/tonne in Central scenario vs. $42/tonne in Central + IRA scenario)
- With the expiration of the tax credits post-2035, the marginal cost converges at the same price in the long run (~$150/tonne)



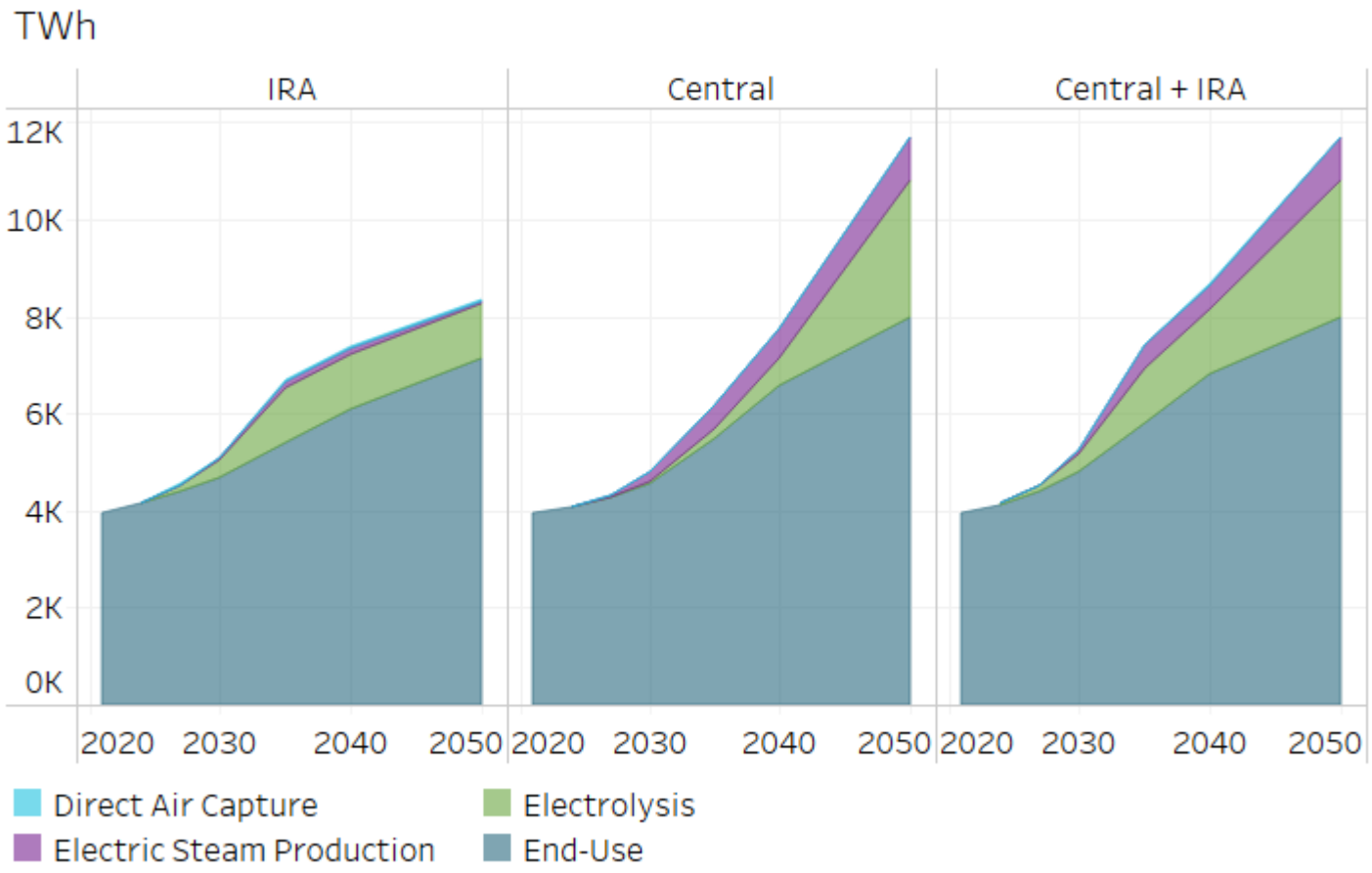
Demand-Side Adoption – Electric Technologies

- Aggressive tax incentives for ZEVs accelerates IRA deployment in the near-term even faster than our assumed deployment in the **Central** scenario
- In the longer-term, incomplete turnover of freight vehicles leaves more ICEs on the road
- Aggressive early building electrification, but limited funding sources exhausts deployment early and results in only modest electrification



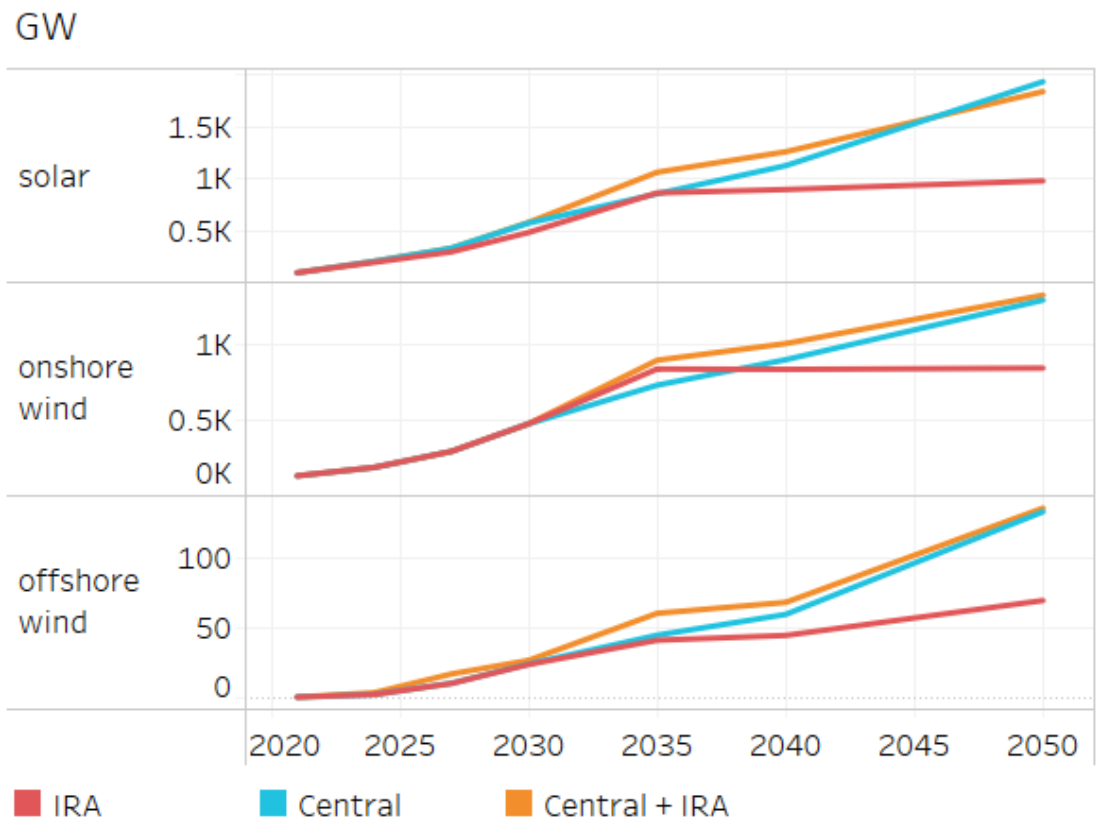
Electricity Demand

- ZEV deployment results in significant end-use load growth
- Hydrogen incentives mean that ~20% of load in 2035 is related to clean hydrogen production
- Limited building and industrial electrification and efficiency leaves a significant amount of pipeline gas in the **IRA** scenario and limits the electricity sector growth compared to **Central** scenario



Renewable Deployment

- Limited policy gap between **Central** and **IRA** deployment through 2035. Post-2035, with the expiration of electricity tax credits, renewable development stalls and would need to be supported with alternative policy mechanisms
- Tax credits in **Central + IRA** accelerate renewable development when compared to the **Central** trajectory



Renewable Build Rates – 2022 to 2030

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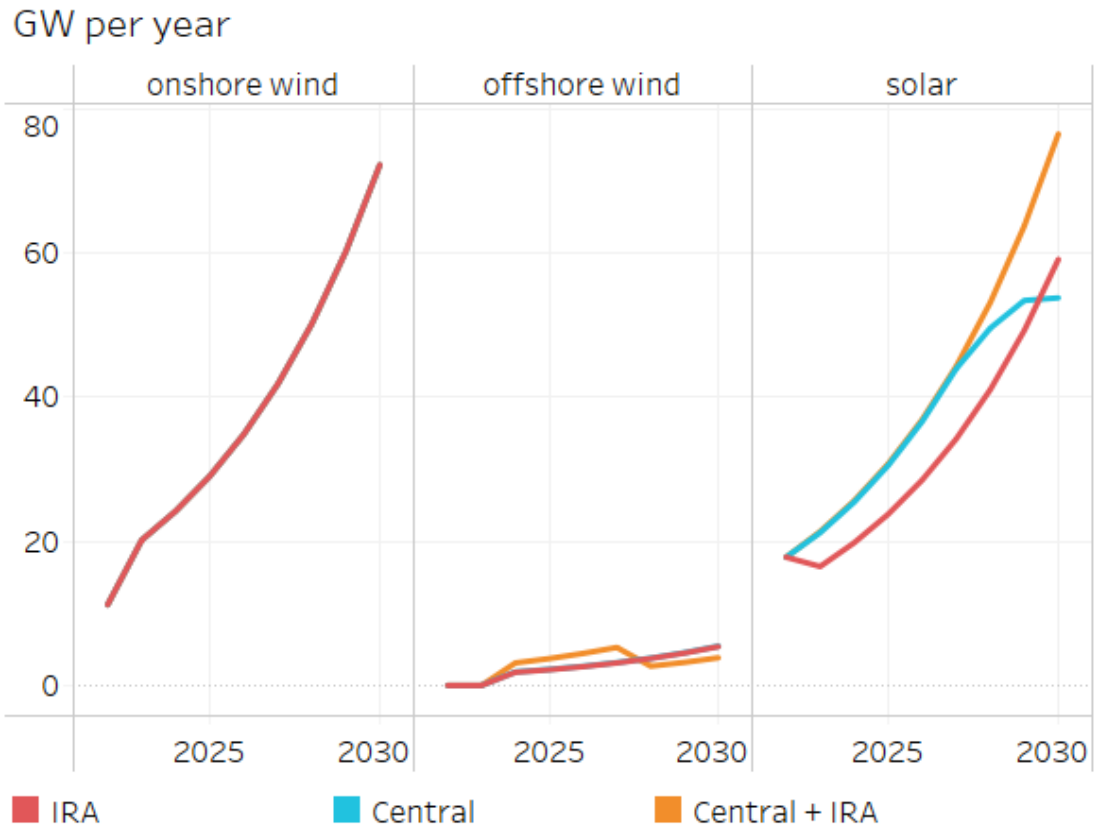
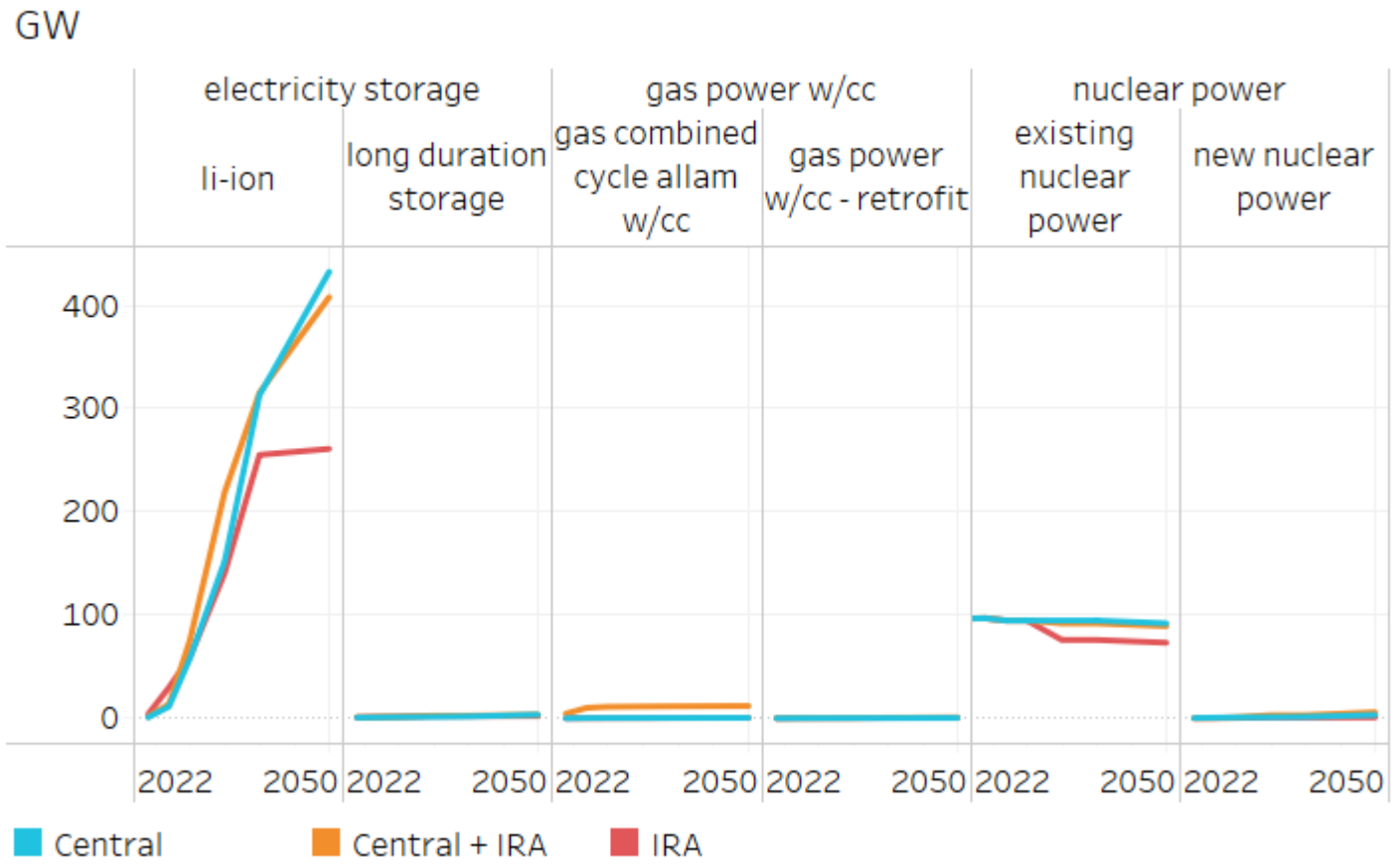
- Model builds all off the onshore wind we allow in the timeframe in all scenarios
  - 2023 is capped at historical max + 20% and all years thereafter are constrained by 20% year-on-year growth rate
- **Central + IRA** scenario maxes solar build, while **IRA** and **Central** scenario is a slower trajectory through 2030
- Offshore wind build is not rate constrained in the modeling, with most of the deployment related to state targets



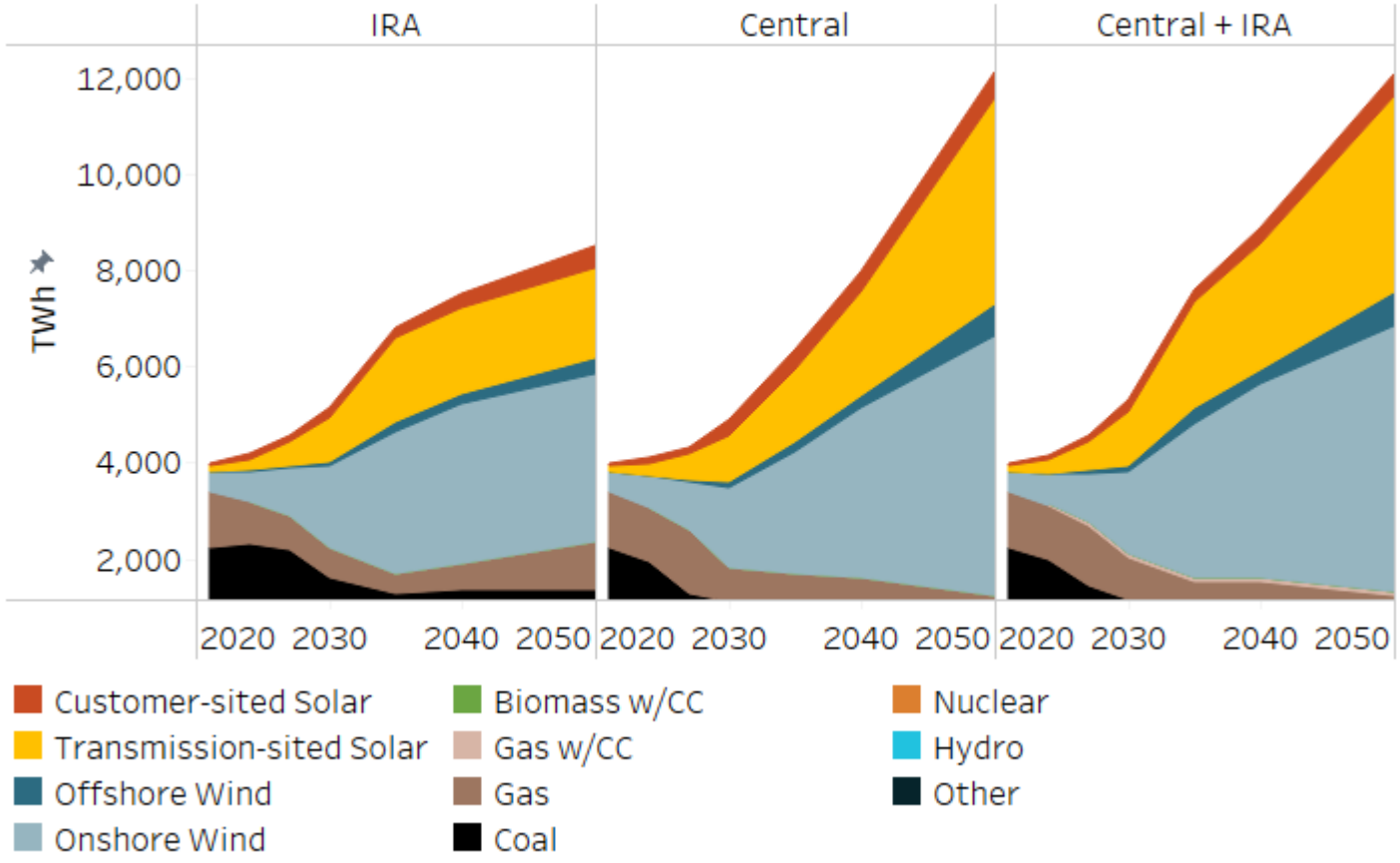
Other Electricity Technologies

- Limited policy gap between **Central** and **IRA** deployment through 2035. Post-2035, similar to renewable deployment, development stalls
- Tax credits maintain existing nuclear through the 2030s before retiring significant amounts by 2035 in **IRA** scenario
- Tax credits in IRA alone not enough to incent significant amounts of gas with carbon capture or new nuclear power. In the **Central + IRA** scenario, however, we do see some deployment of both



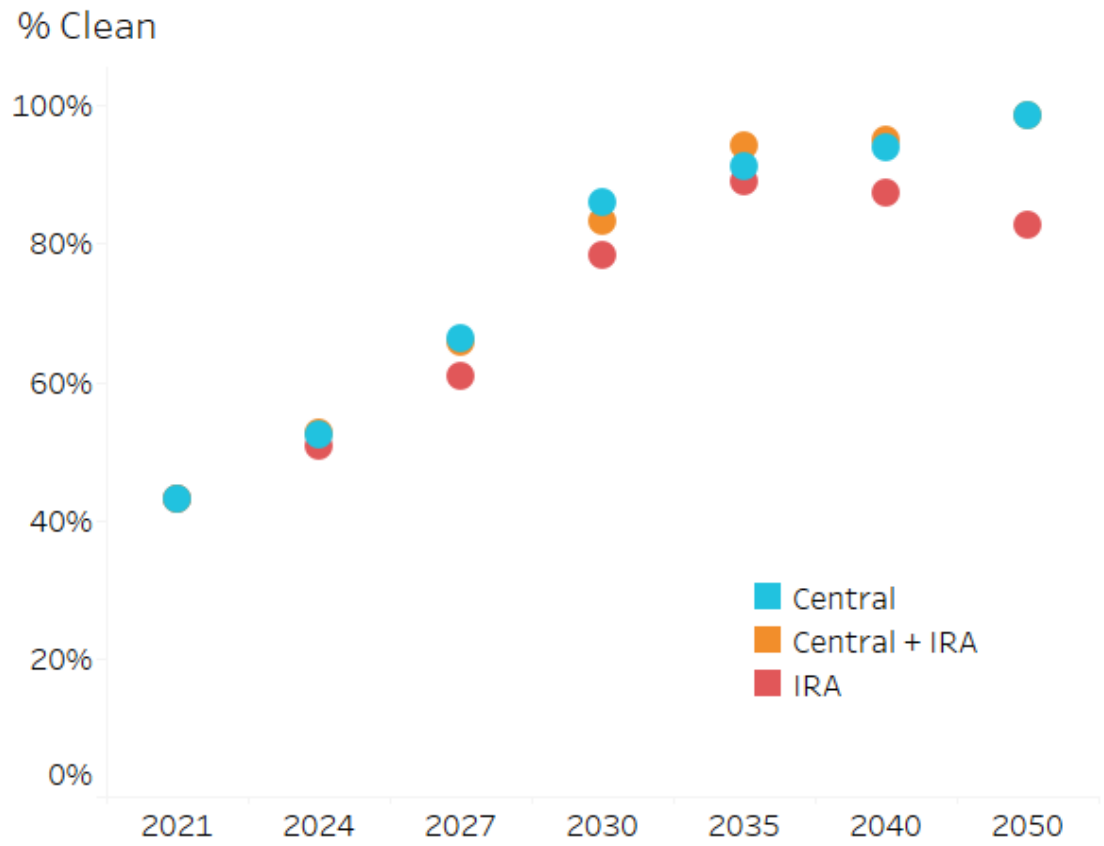
Electricity Generation

- Limitation of IRA is in reducing remaining coal. Significant amount driven off from renewable deployment, but large amounts of coal exist in areas with higher-cost renewables (i.e. southeast, upper Midwest)
- Post-2035, load growth from continuing vehicle electrification is satisfied by increased gas generation in IRA scenario whereas other scenarios continue renewable deployment

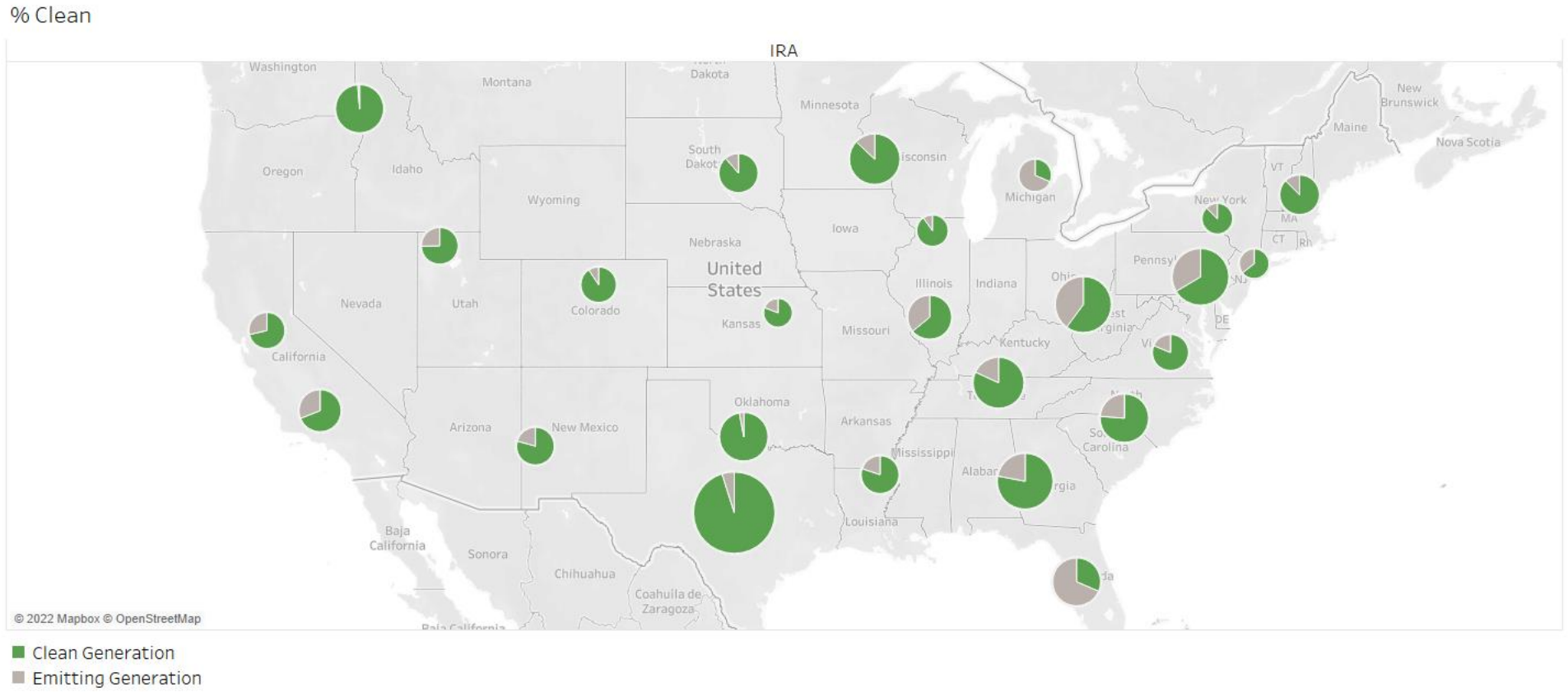


Clean Electricity Share

- Deployment (principally of renewables) at early stages follow optimal trajectory in **IRA** scenario
- As renewable resource quality declines and cost increase with more integration solutions necessary, there is a slight decrease from the optimal in terms of clean generation share
- In the long-term, expiring renewable incentives in **IRA** mean overall clean generation share declines from 2035-2050

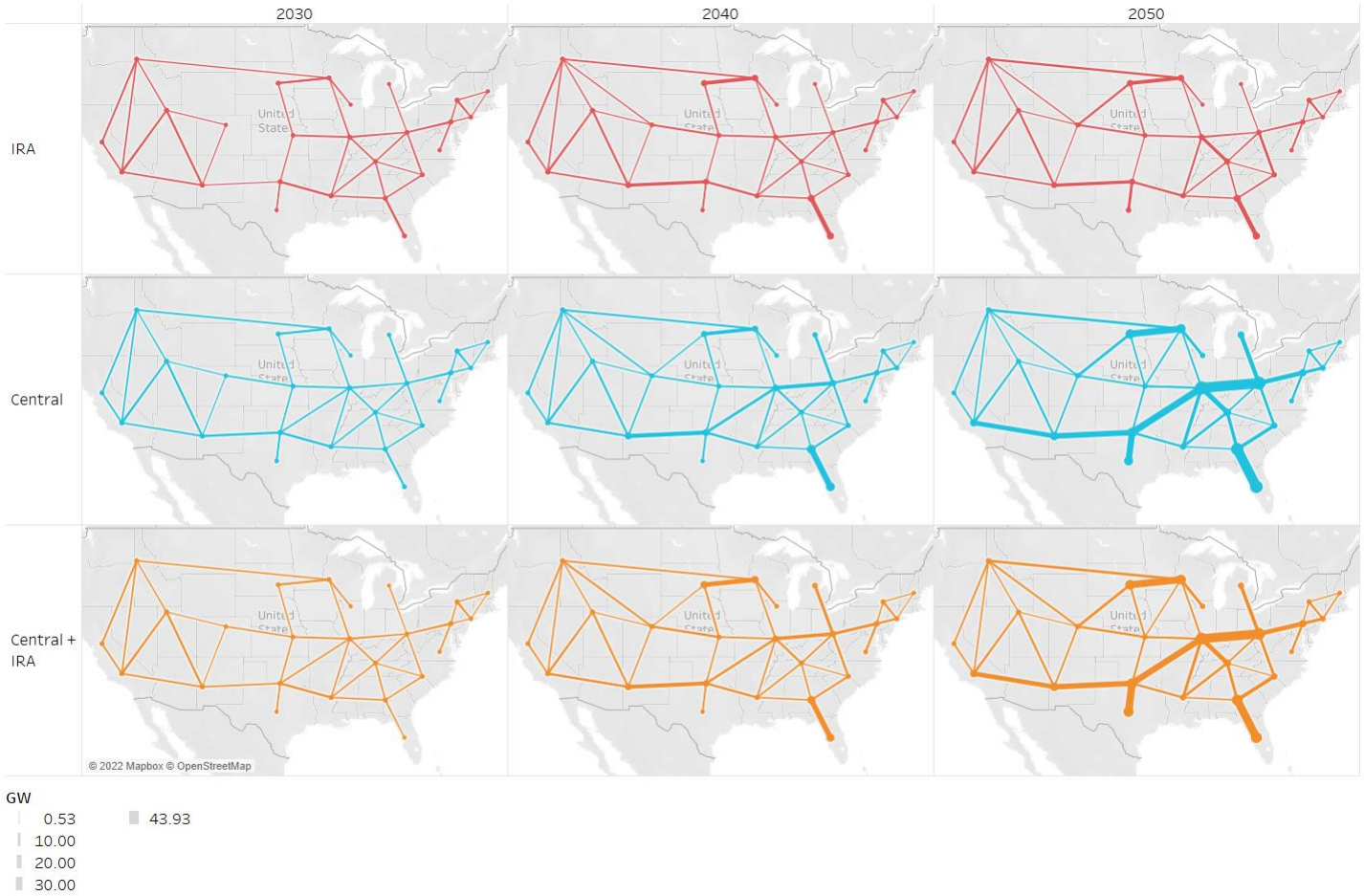


Clean Electricity Share by Zone - IRA



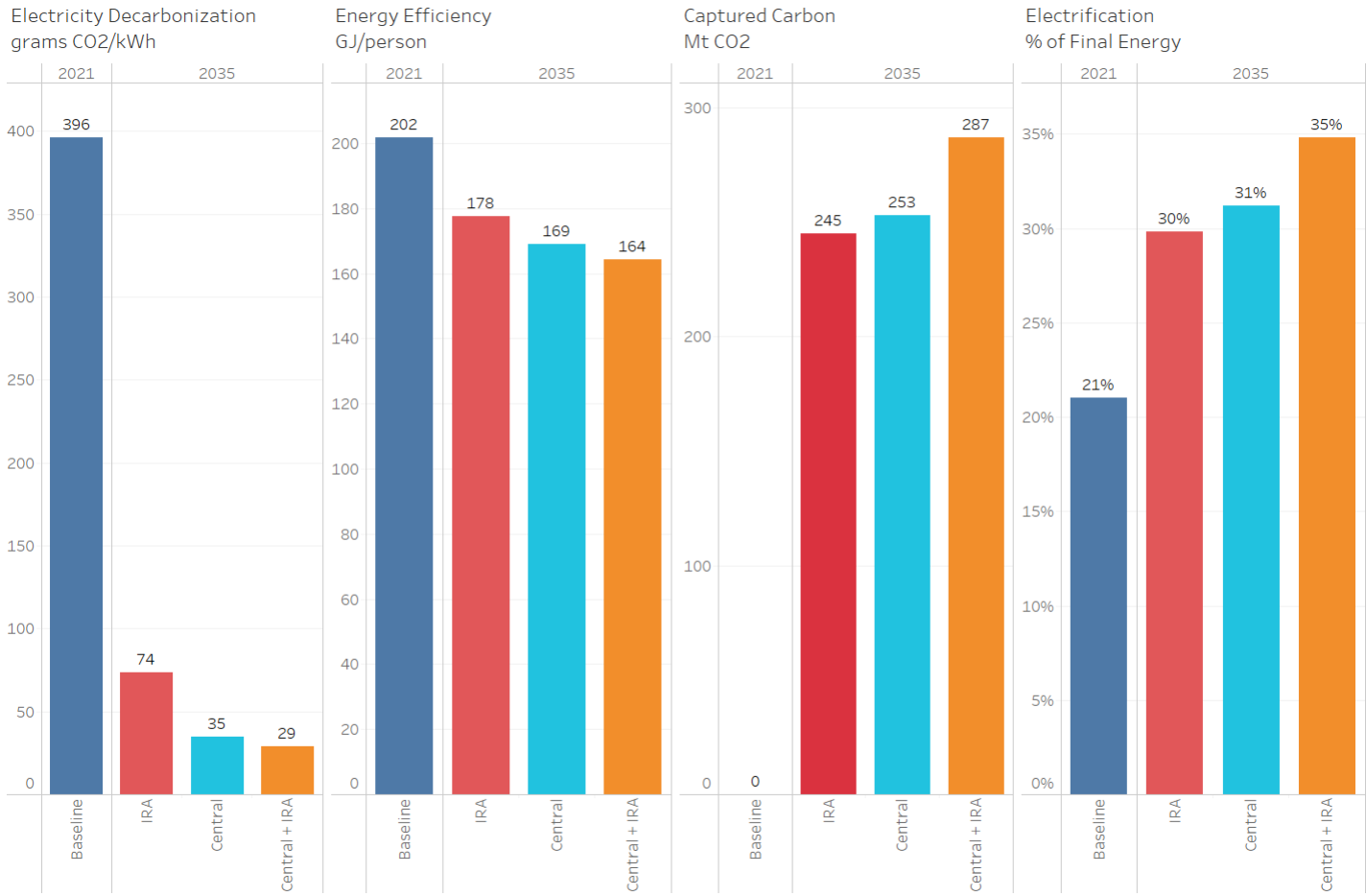
Interregional Transmission Development

- IRA doesn't incent a significant amount of large-scale regional transmission (incentives not enough to pay for clean electricity and transmission to displace fossil generation)
- In the long-term we see transmission development from the wind-belt towards the costs. Scale of transmission somewhat mitigated by the ability to move renewables in different forms (H2 pipelines, ammonia pipelines, liquid pipelines)



Four Pillars Comparison: 2035

- The inability to specifically target coal for emissions reduction limits electricity decarbonization even with rapid deployment
- Relatively less support for buildings and industry reduces energy efficiency and electrification progress
- Achievement of carbon capture targets, though sources vary from **Central** scenario



Four Pillars Comparison: 2050

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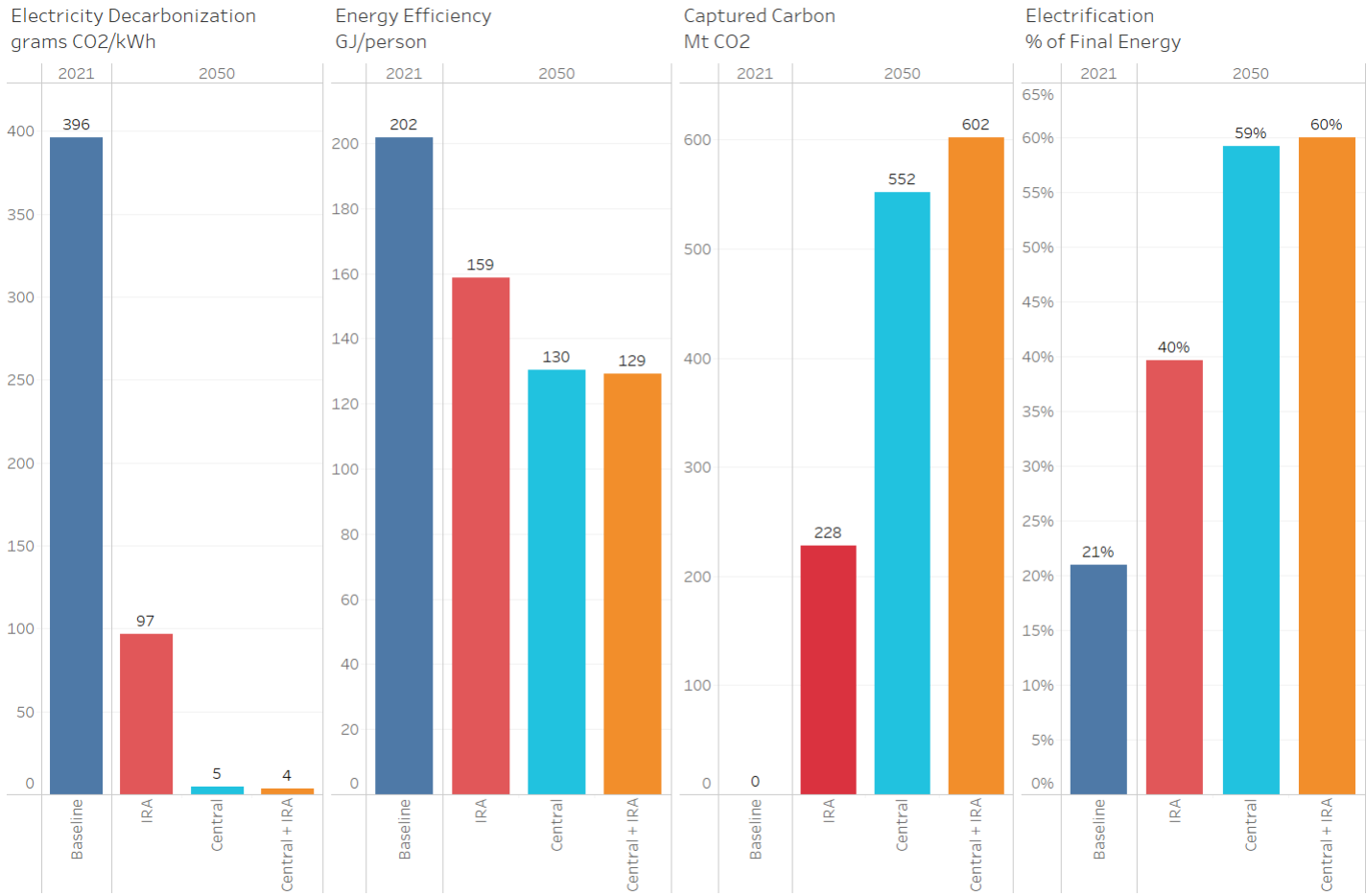
- Expiration of clean energy tax credits plateaus emissions reductions progress from electricity
- Vehicle electrification progress has continued, though slowed, but buildings and industry still fueled by significant amounts of natural gas
- Lack of continued support for zero-carbon fuels and CO2 capture stalls expansion of carbon management sector



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Conclusions

What areas of deep decarbonization are supported by the IRA? Where are the gaps?

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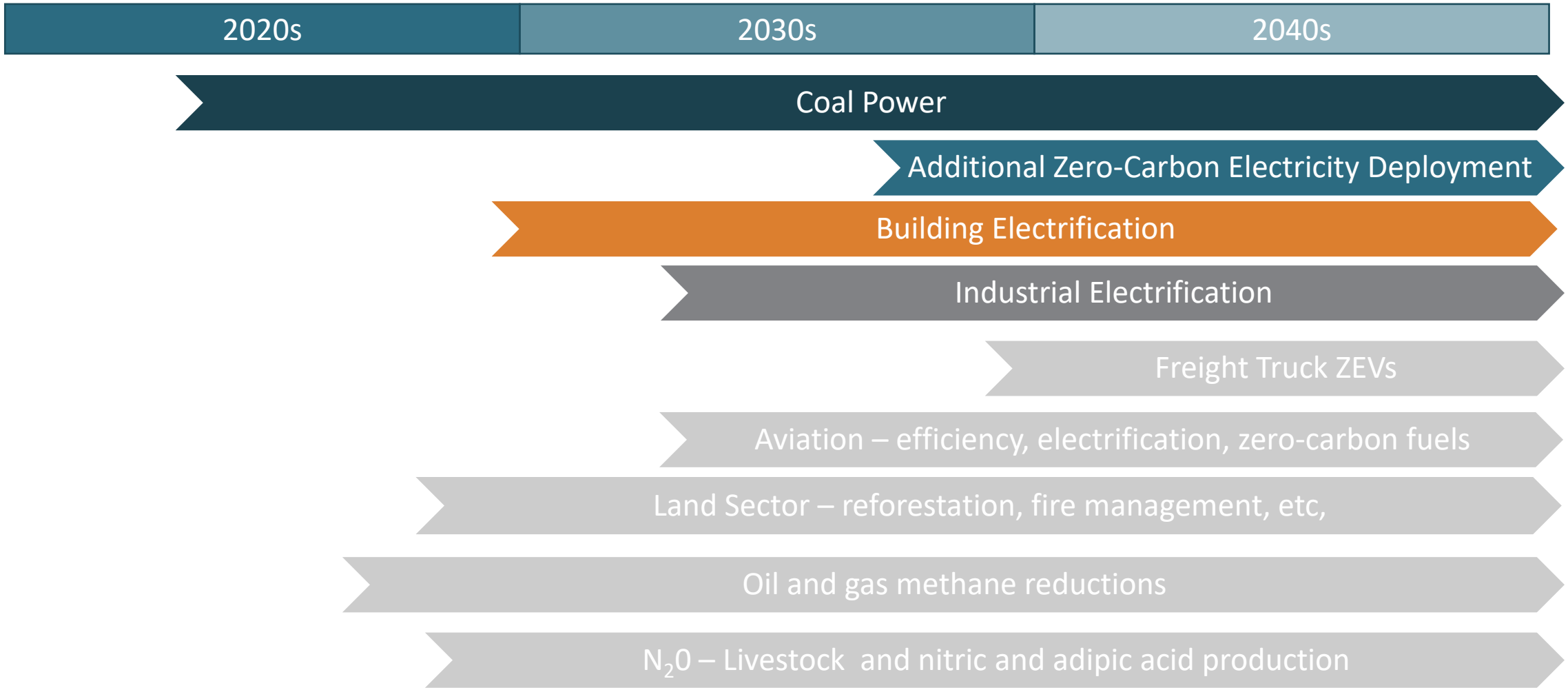

What are the opportunities for regulatory policy, state policy, and technology progress to address those gaps?

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Scenario	Federal Regulatory Policy	State Policy	Technology Development
Coal Power	Clean Air Act – Section 111	Clean energy standards	Nuclear SMR and Gas w/CC development for retrofitting of existing sites
Additional Zero-Carbon Electricity Deployment	Clean Air Act – Section 111; additionality requirements for clean hydrogen deployment; interregional siting reform	Clean energy standards; rate design to encourage non-storage integration solutions; siting reform	Thermal energy storage; lower-cost electricity storage; nuclear, geothermal, offshore wind and gas w/cc technology development for areas with limited onshore wind and solar
Building Electrification		New gas hookup moratoriums; targeted electrification programs	Low-temperature heat pumps; broader heat pump technology offerings; smart controls
Industrial Electrification		Rate design to encourage flexible clean heating technologies (thermal energy storage, dual fuel boilers, etc.)	

Does the relative weight of policy ambition in the IRA change the optimal decarbonization strategy?

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- This question is addressed directly by our **Central + IRA** scenario which sees:
  - Heavy reliance on the deployment of renewables and EVs, two of the most cost-effective opportunities for near-term mitigation. This reliance, however, will be challenging for supply chains.
  - Accelerating timelines for technology development and deployment of clean hydrogen technologies which has implications for renewable deployment and reductions in the sector
  - Scenario sees the deployment of some gas with carbon capture to take advantage of 45Q

Other Conclusions

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- The IRA does a very good job at incenting deep decarbonization energy system activities in the near to medium-term
- Post-2035, continued emissions reductions would need to be supported by the continuation of federal policy or state policy
- As a general principle, we would note that models are potentially too optimistic in near-term and pessimistic in the long-term
  - Near-term supply chain impacts, bottlenecks, and increased technology prices may hinder deployment of key technologies
  - But long-term, “knock-on” effects of the IRA may make larger impacts than modeled here. Difficult to assess market transformation impacts of more limited funding in building electrification, advanced manufacturing, and R&D activities. Also doesn’t capture increased state policy and corporate ambition that accompanies technology demonstration and cost declines.

THANK YOU

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