

# **Historical precedents and feasibility of rapid fossil fuel decline required for climate targets**

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**Physical Resource Theory | Chalmers University of Technology**

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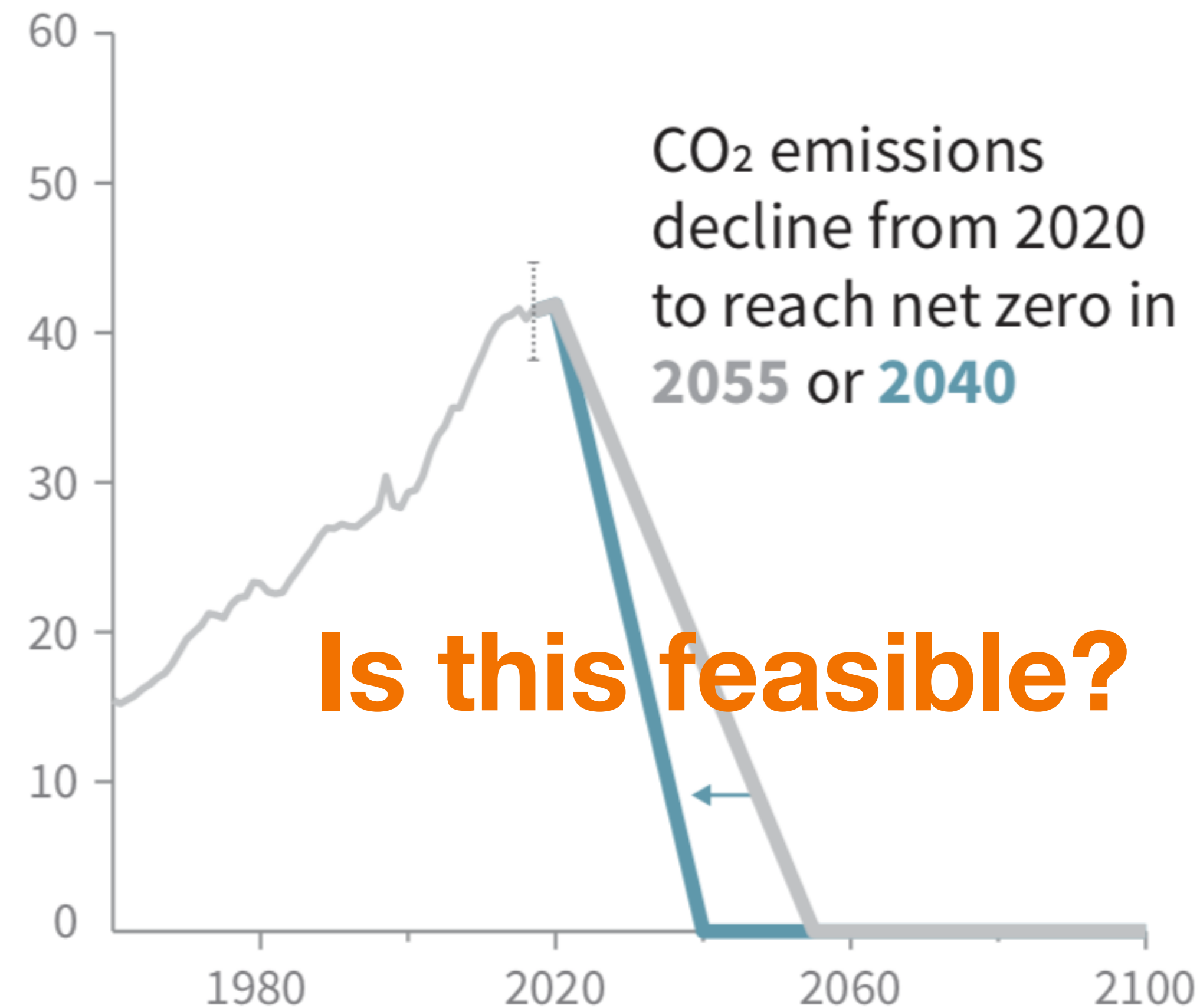
**11 January 2022**

**POLET workshop on fossil fuel decline**

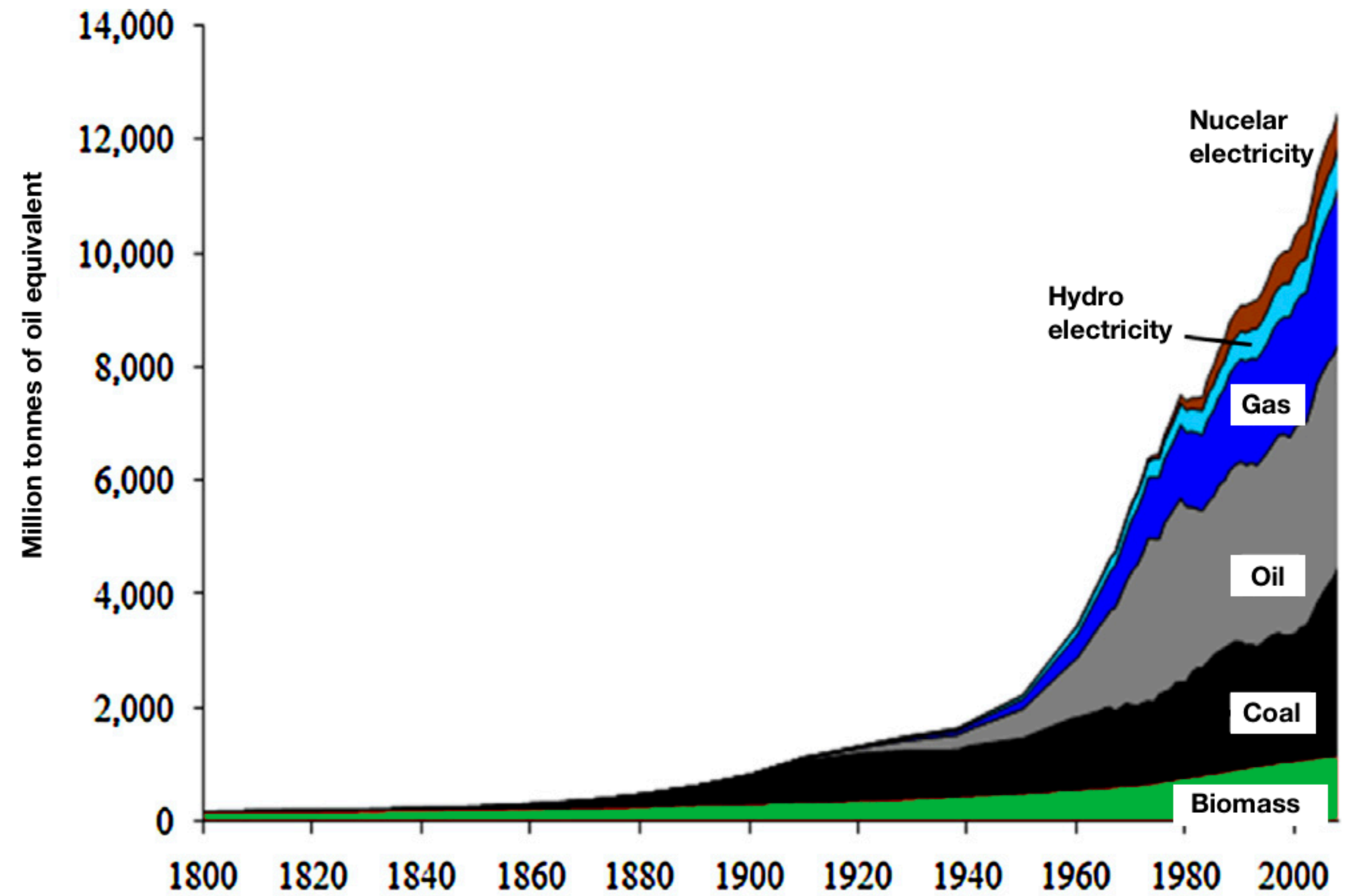
Vinichenko, V., Cherp, A. and Jewell, J., 2021. Historical precedents and feasibility of rapid coal and gas decline required for the 1.5°C target. *One Earth*, **4(10)**, pp. 1477-1490.  
[doi: 10.1016/j.oneear.2021.09.012](https://doi.org/10.1016/j.oneear.2021.09.012)

# Dramatic decrease emissions to meet climate targets

b) Stylized net global CO<sub>2</sub> emission pathways  
Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



# How do we know what's feasible in the real world?

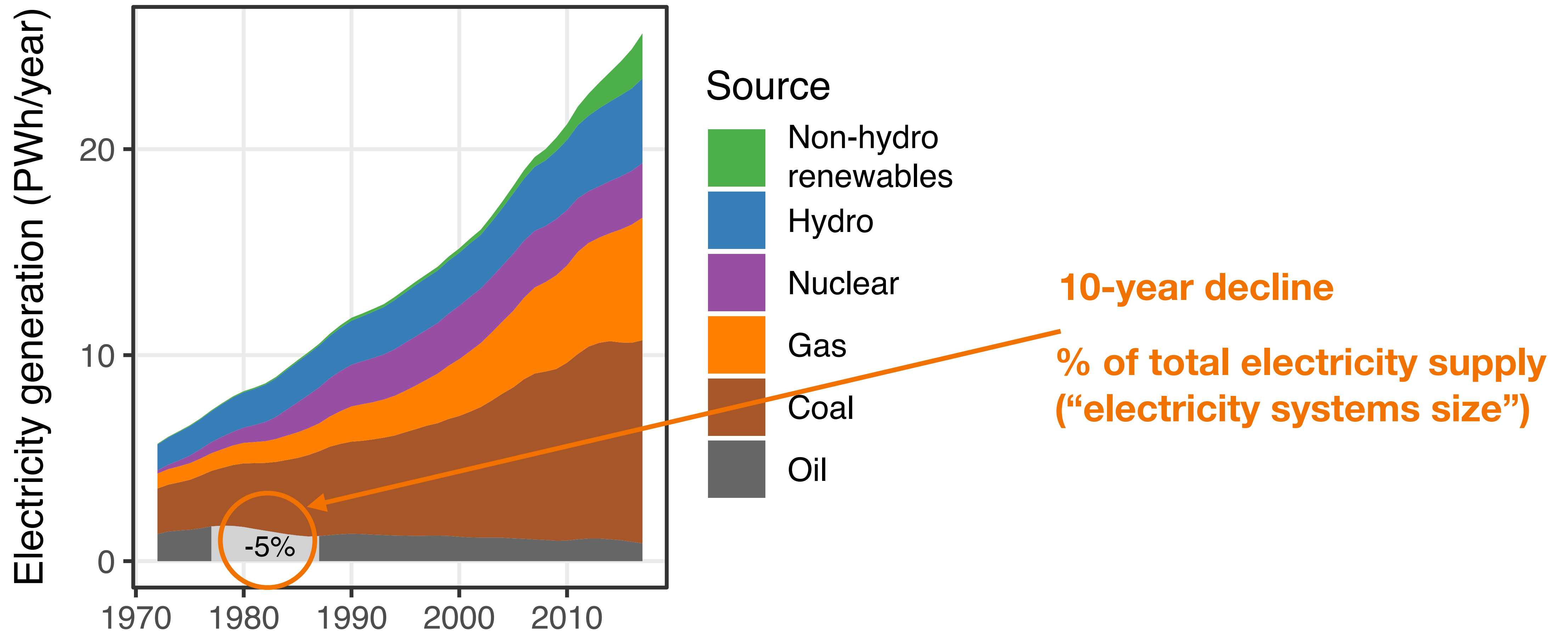


Fouquet 2016

# Examining fossil fuel decline in electricity

Globally one episode of decline in the 1970s/1980s

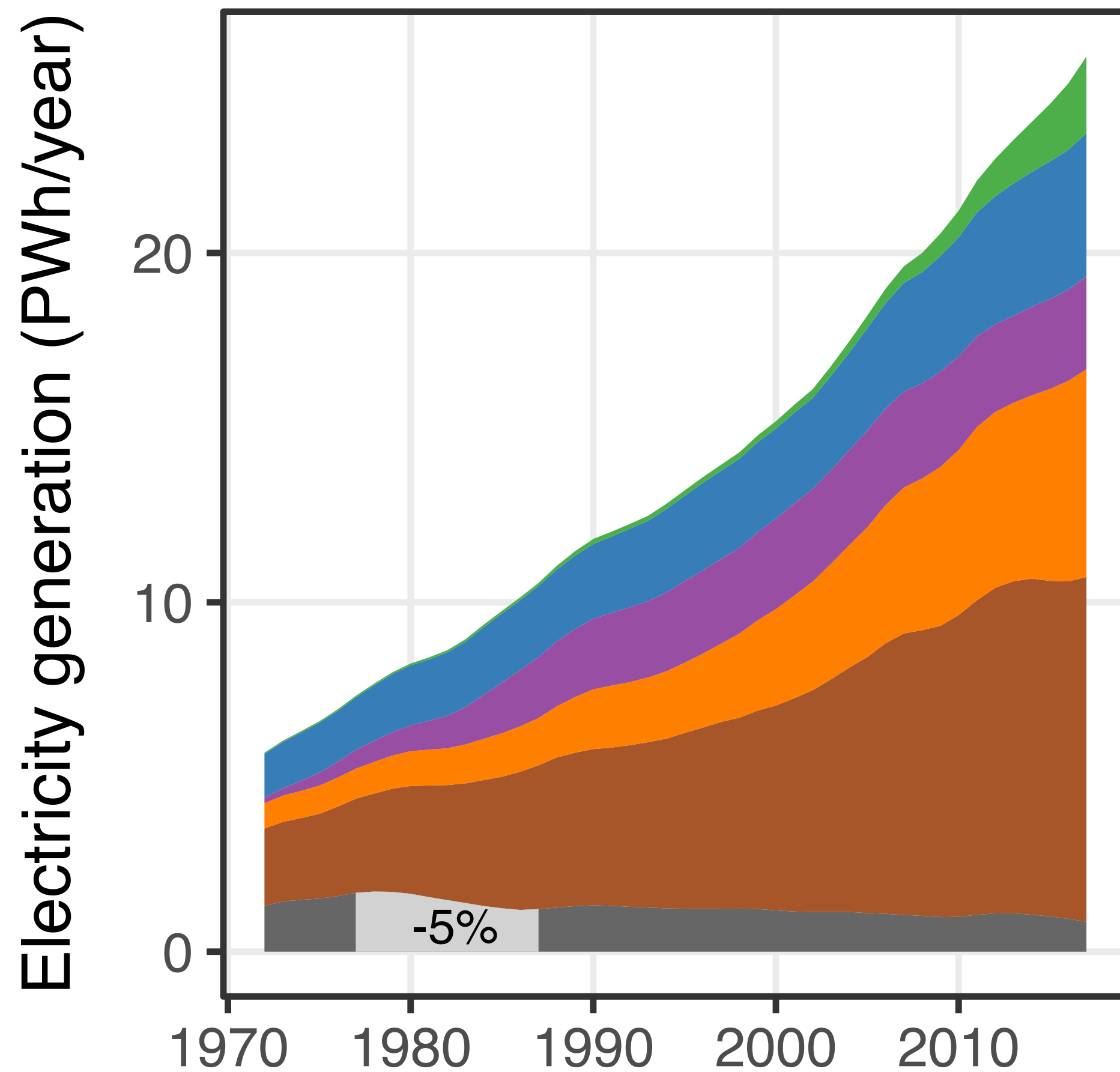
(a) World



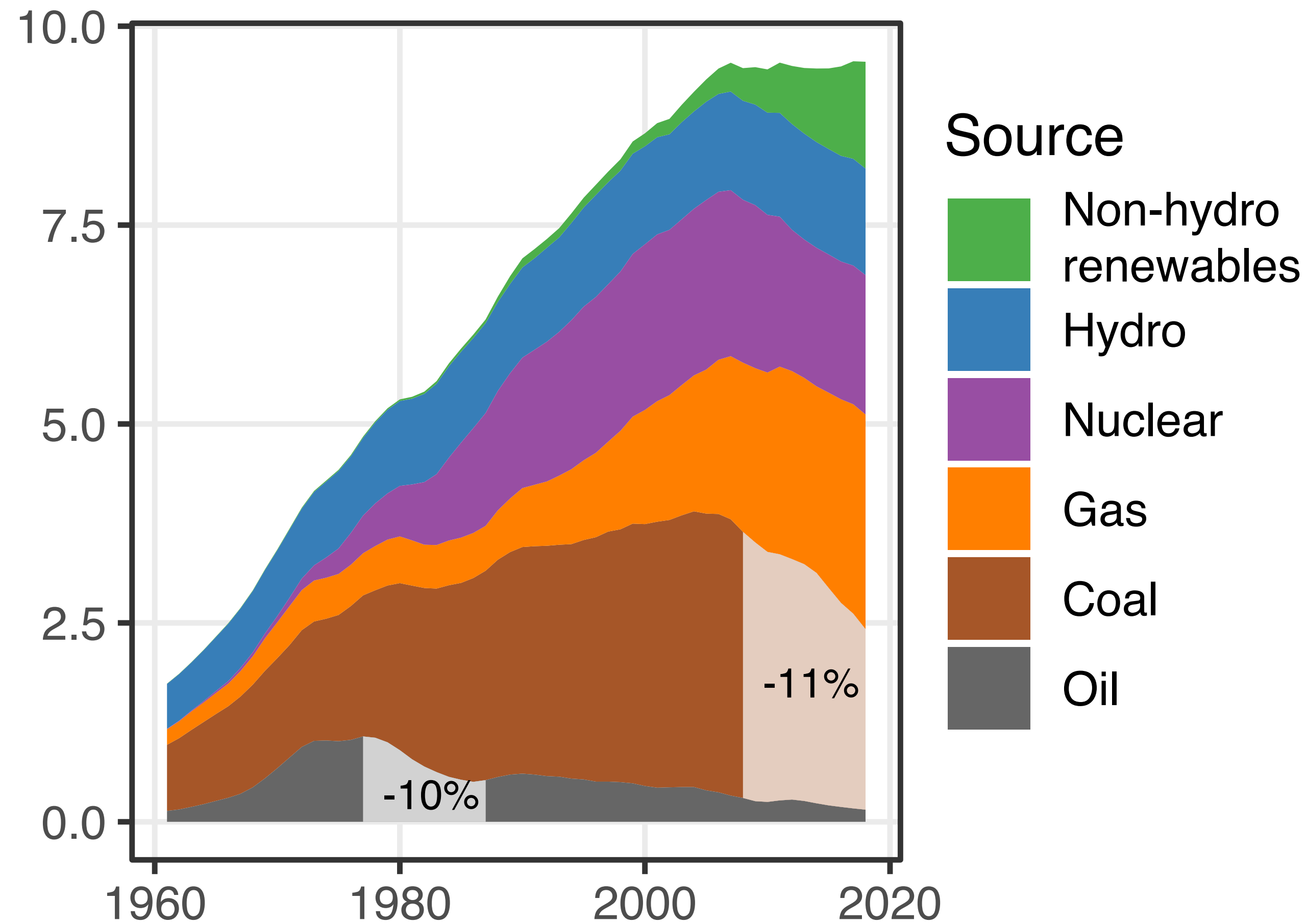
# Examining fossil fuel decline in electricity

## Examples of regional decline episodes

(a) World



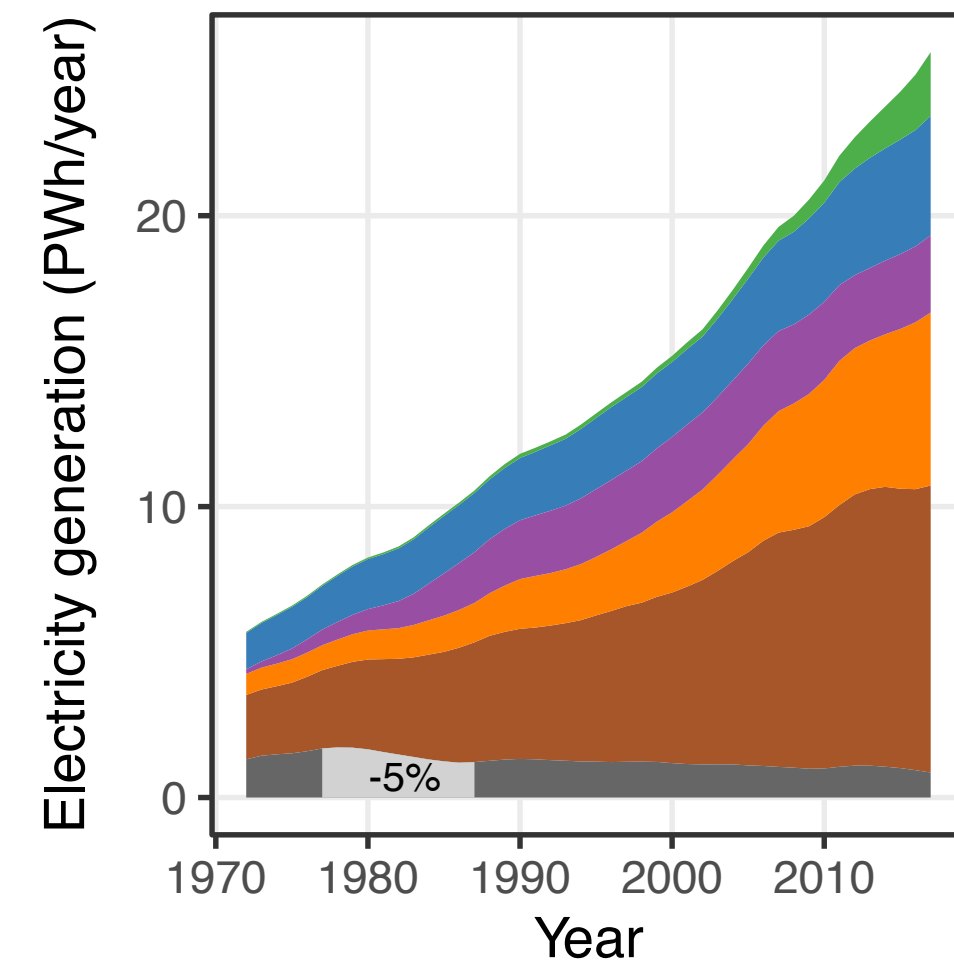
(b) OECD



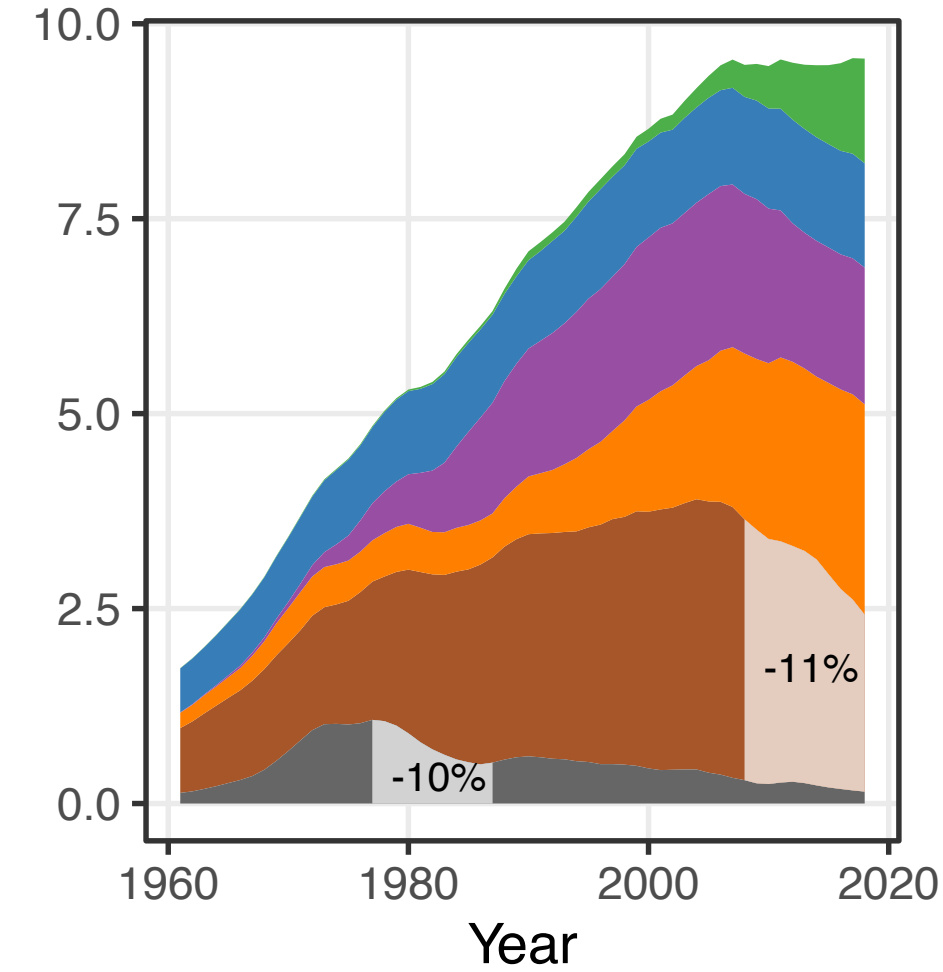
# Examining fossil fuel decline in electricity

## Examples of regional and national decline episodes

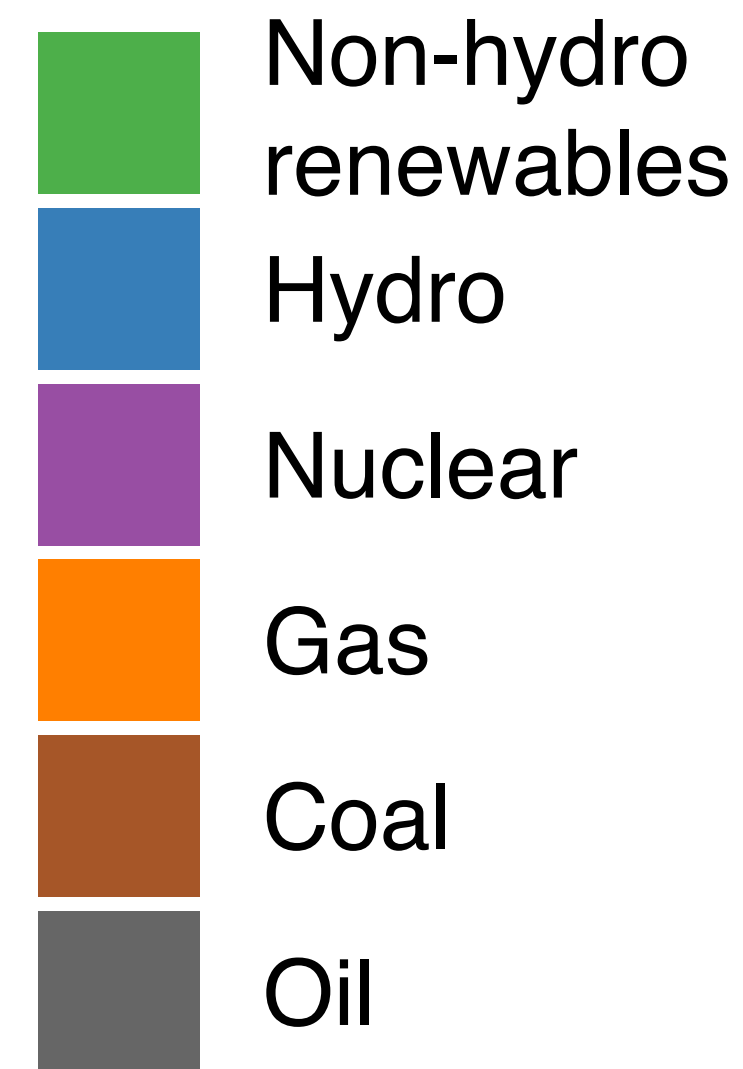
(a) World



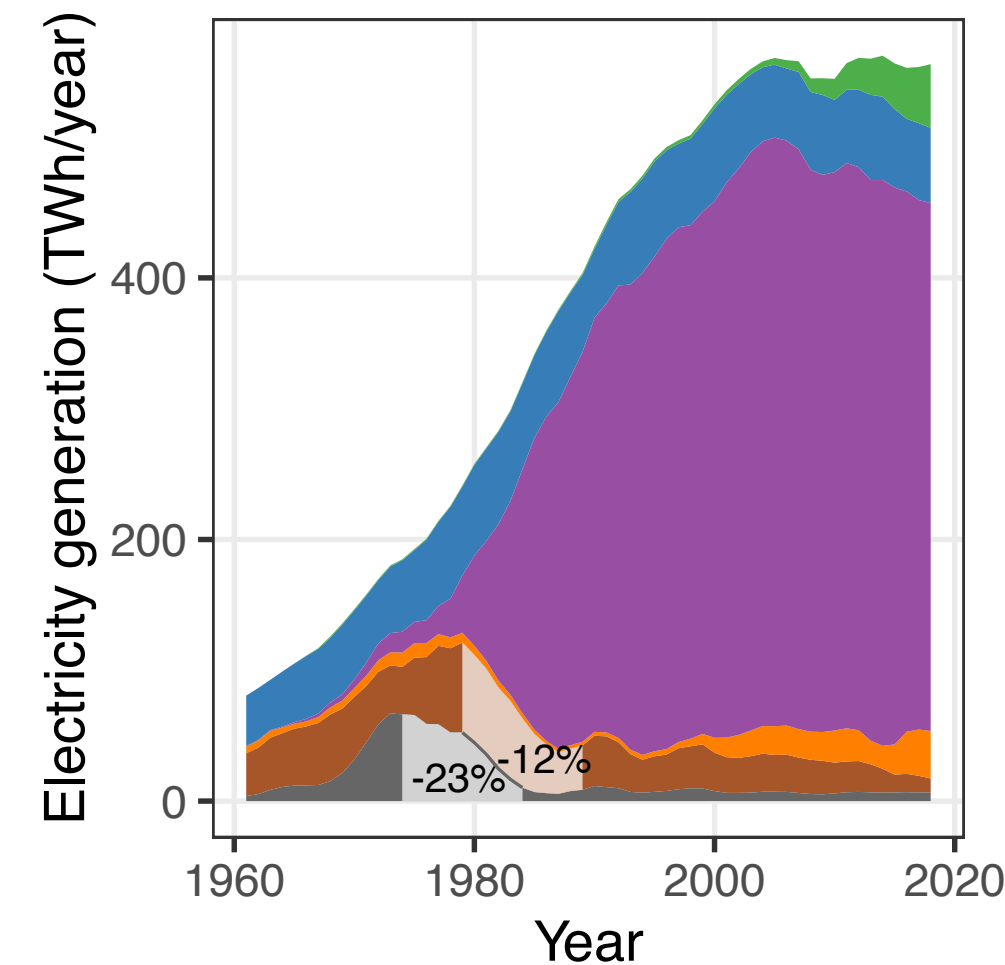
(b) OECD



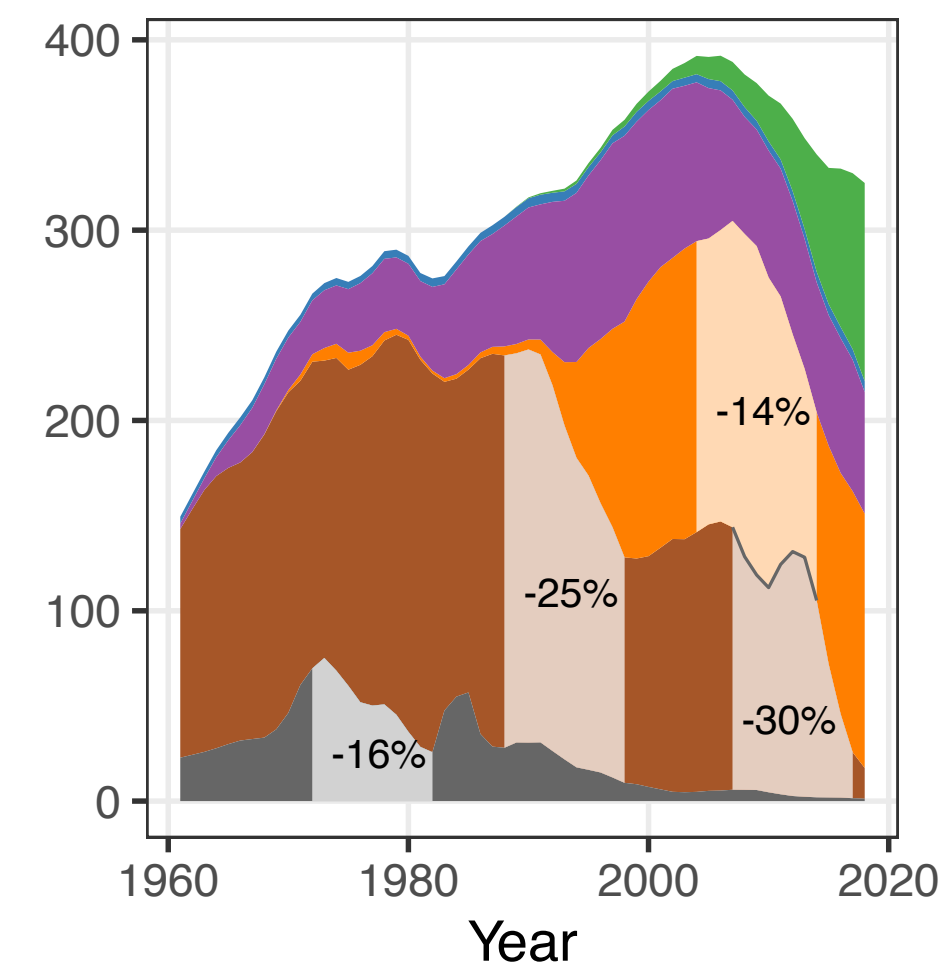
### Source



(d) France

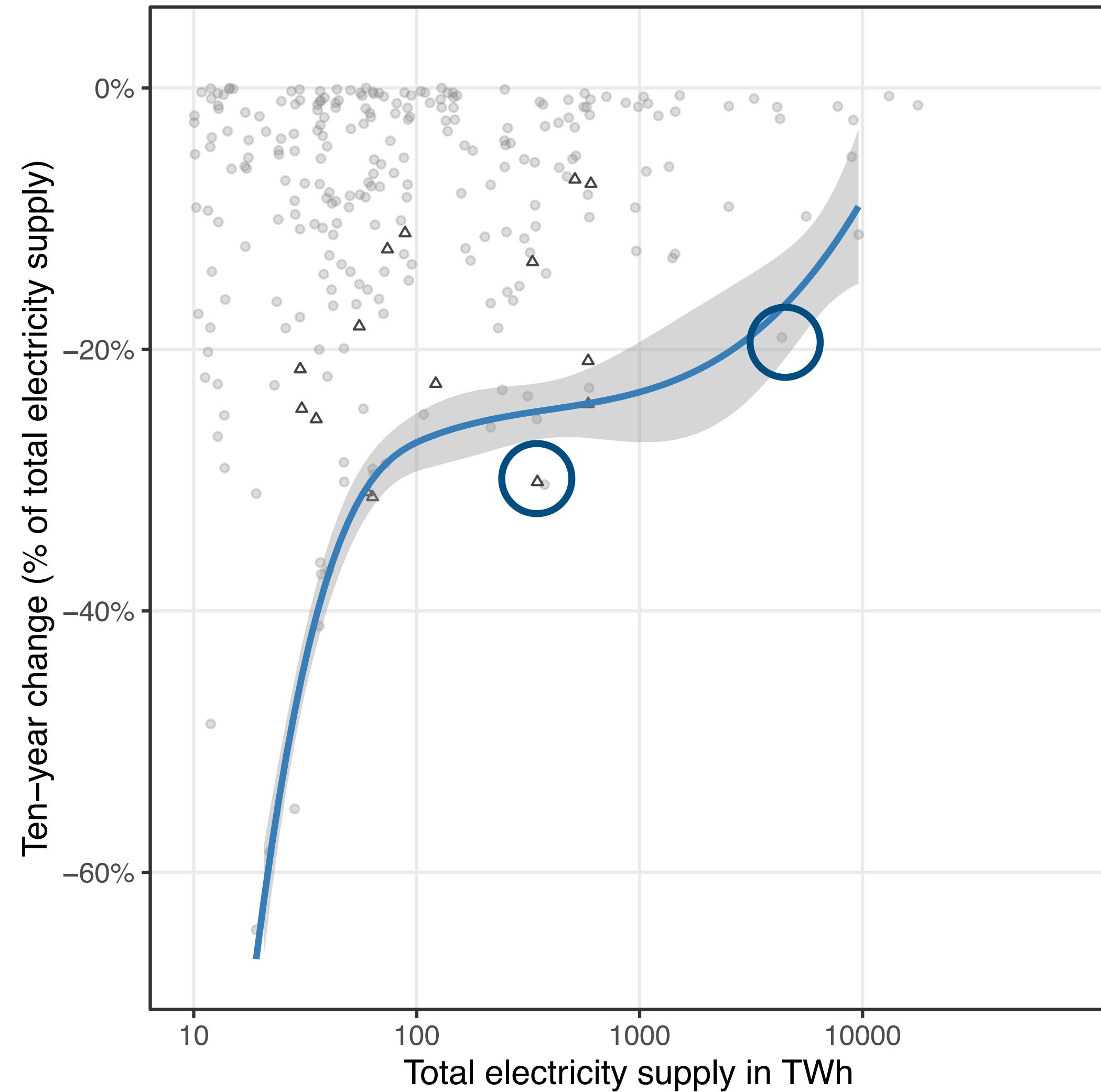


(e) United Kingdom



# Episodes of fossil fuel decline

## Smaller systems achieve faster decline rates

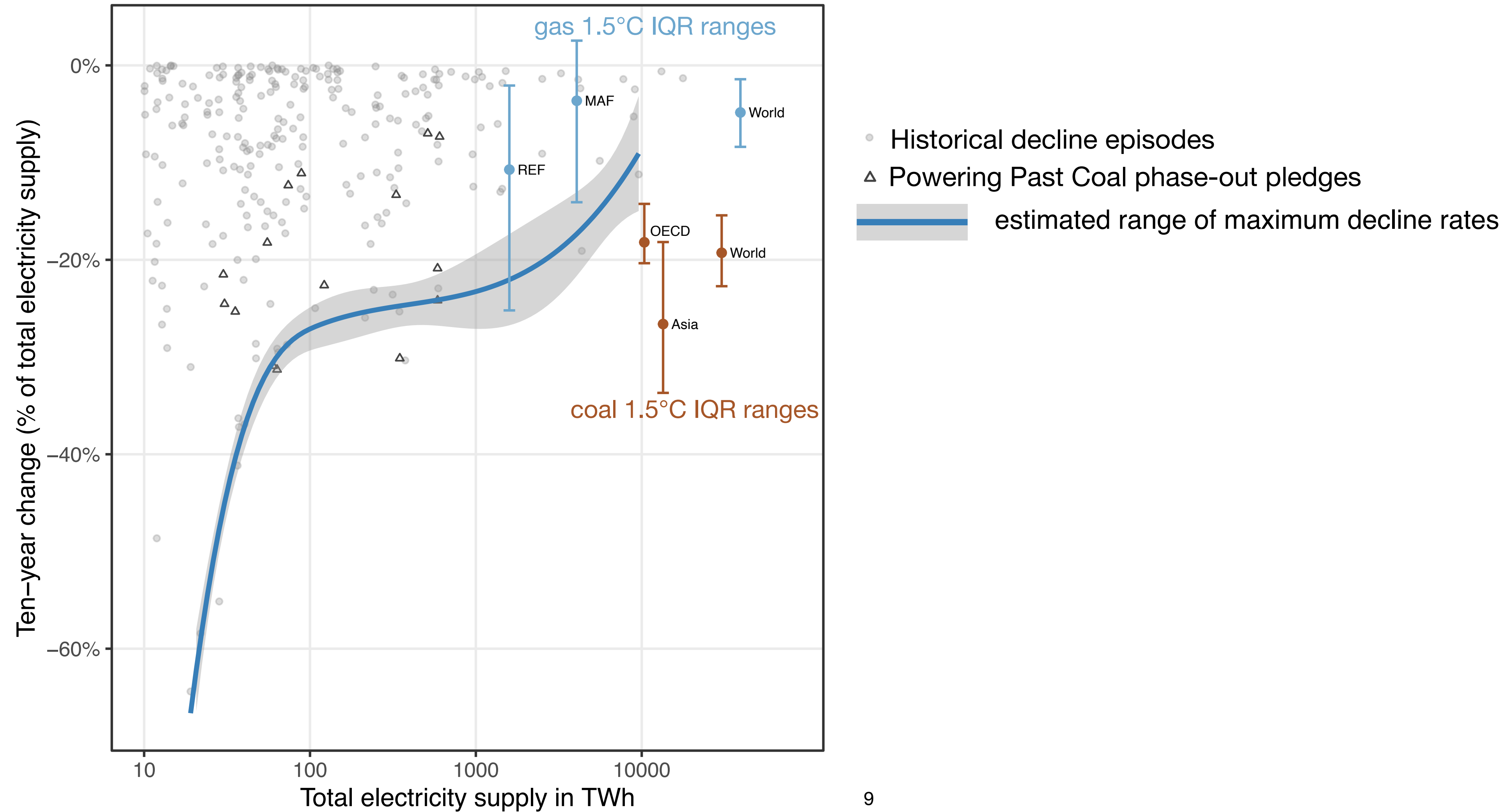


- Historical decline episodes
- △ Powering Past Coal phase-out pledges
- estimated range of maximum decline rates



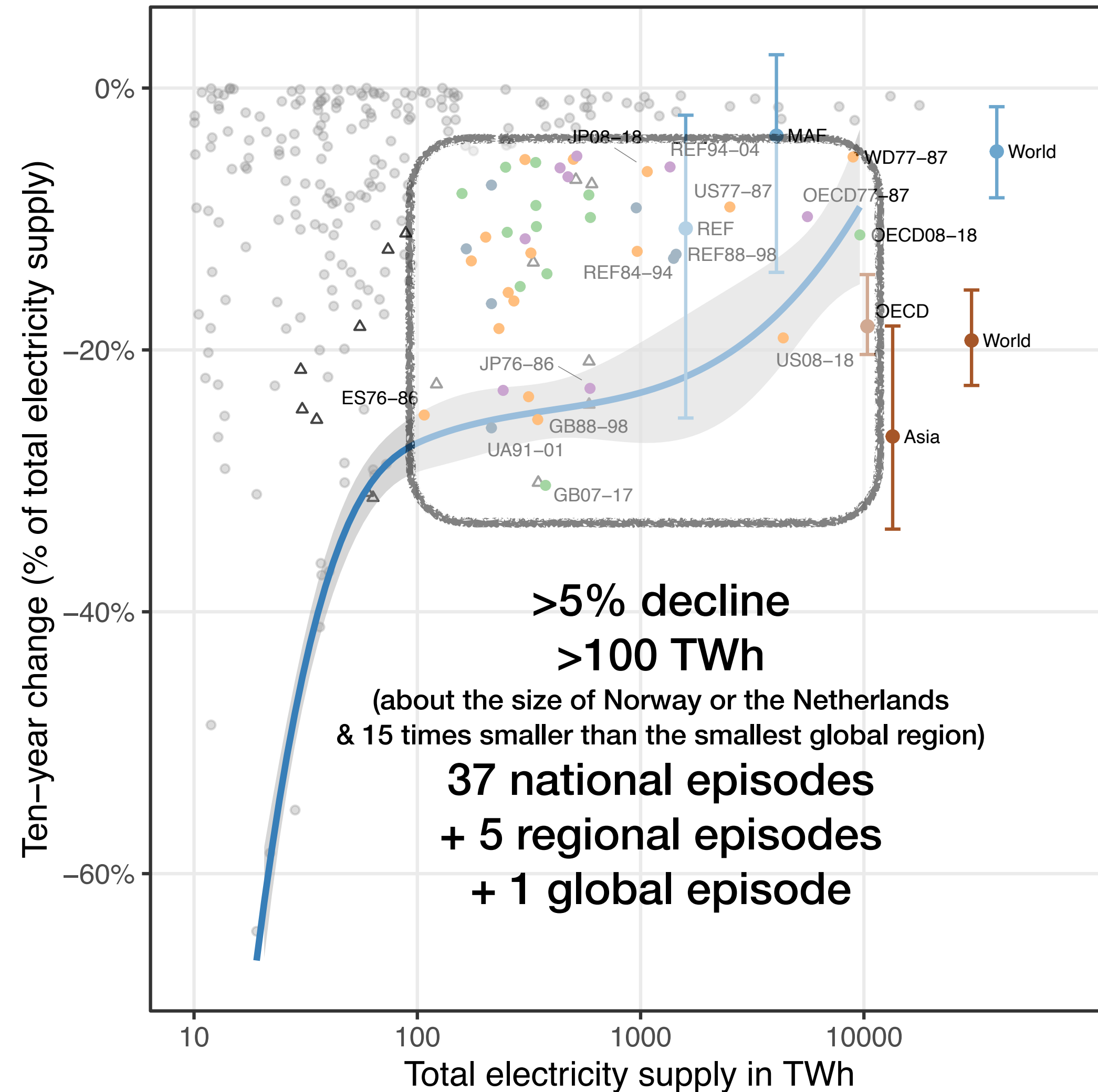
# Episodes of fossil fuel decline

## Smaller systems achieve faster decline rates



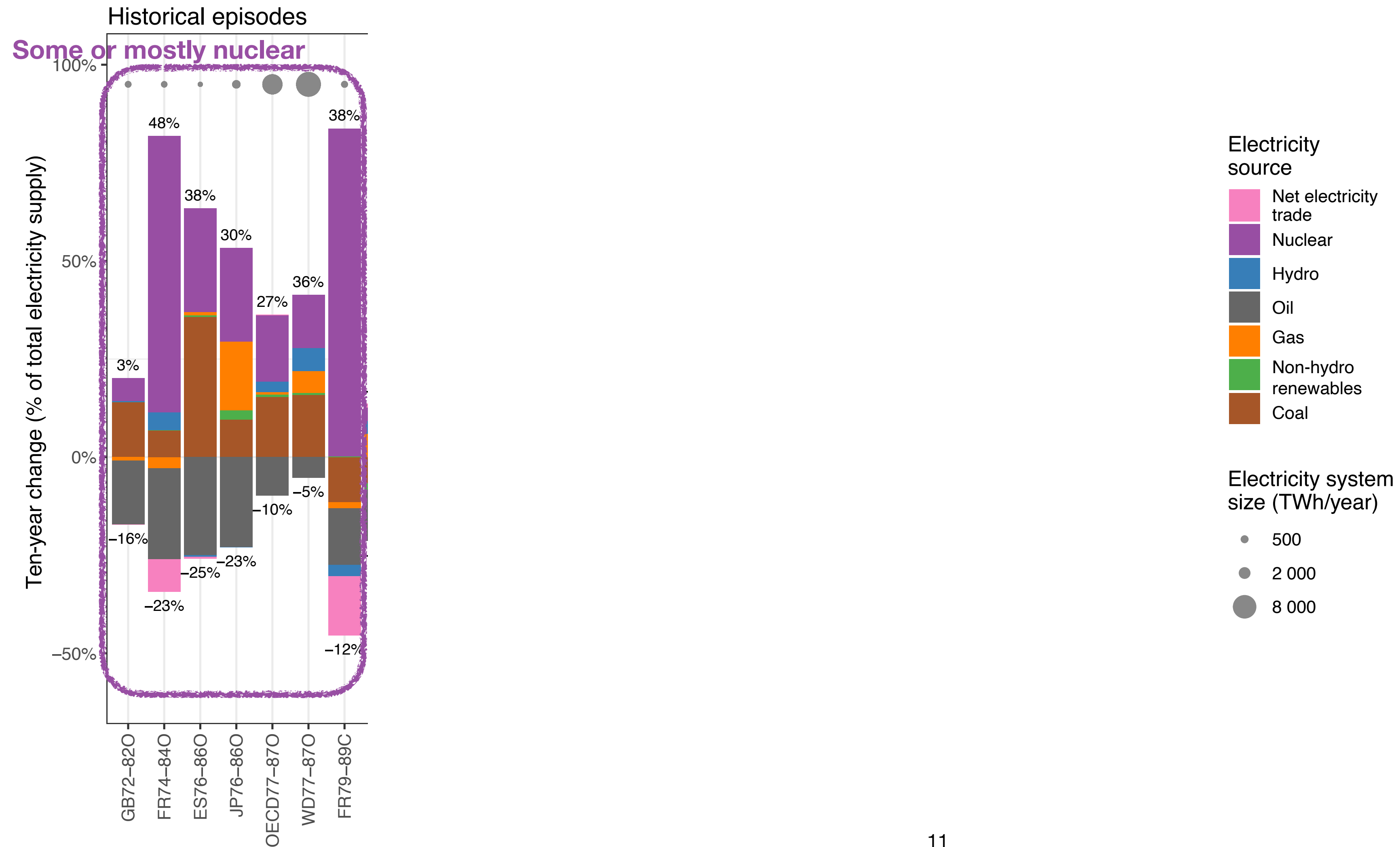
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## Smaller systems achieve faster decline rates

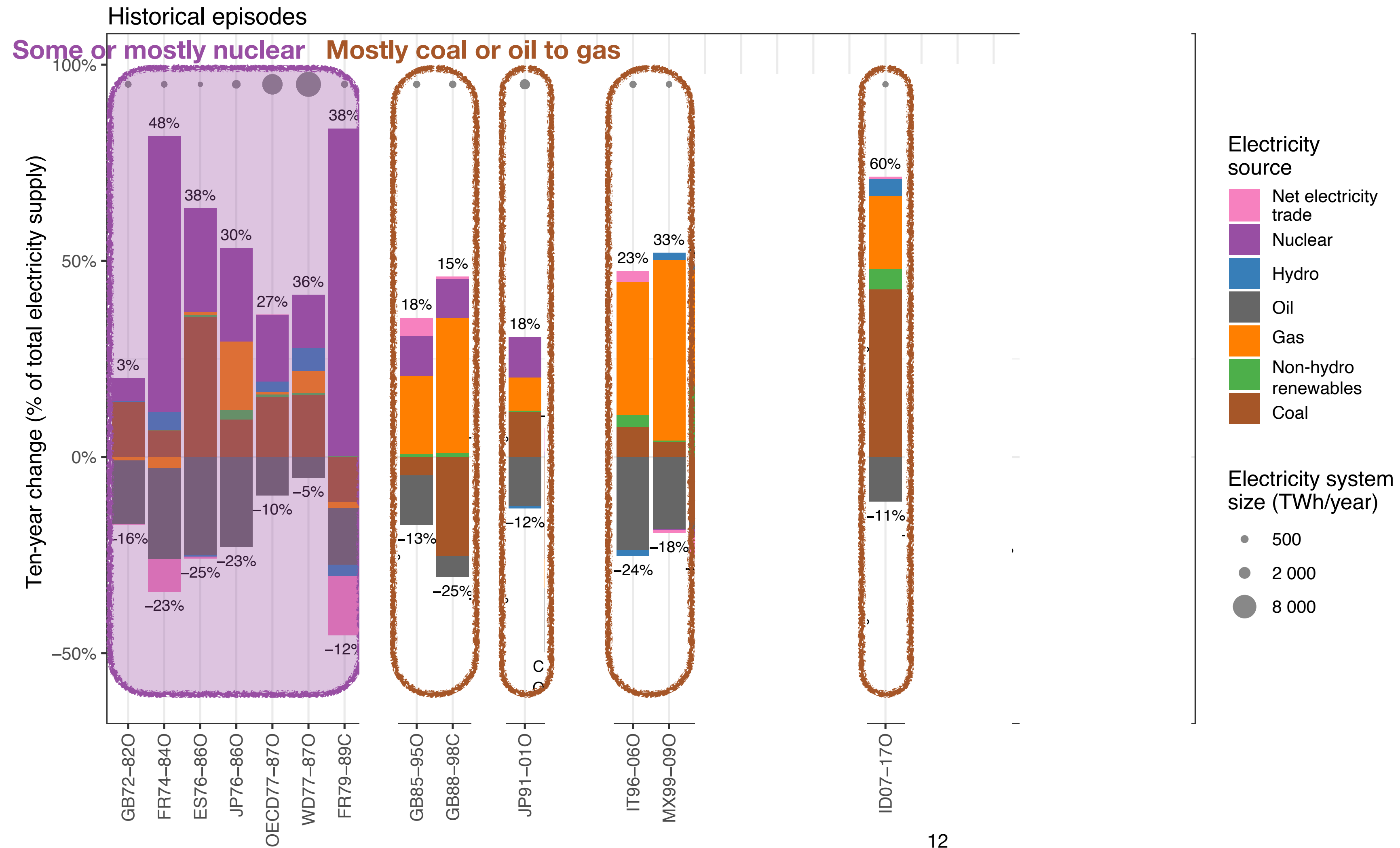


- Historical decline episodes
  - △ Powering Past Coal phase-out pledges
  - estimated range of maximum decline rates
- Primary substitution in historical decline episodes
- Demand decline
  - Fuel switching
  - Nuclear
  - Renewables

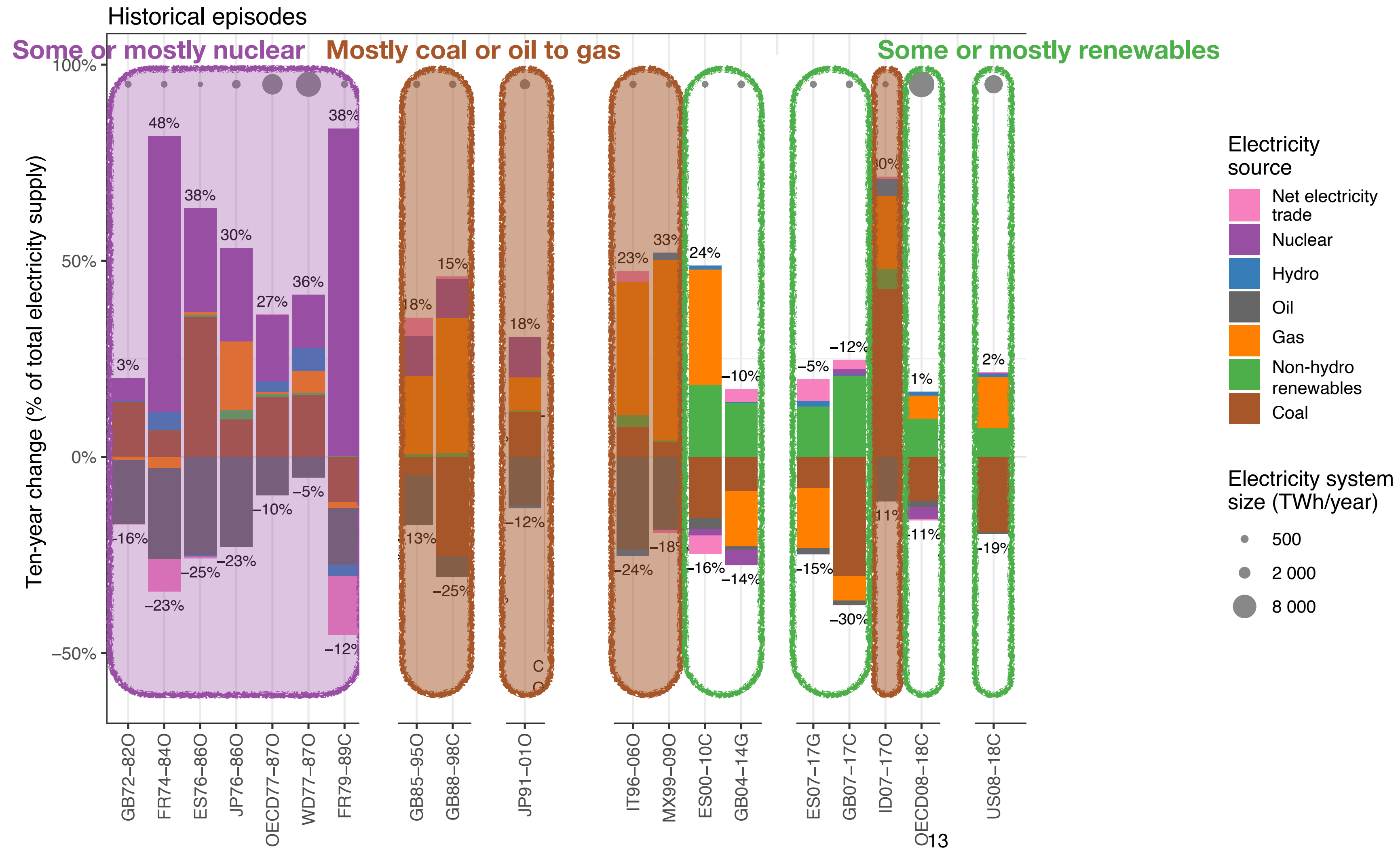
# What substitutes fossil fuels?



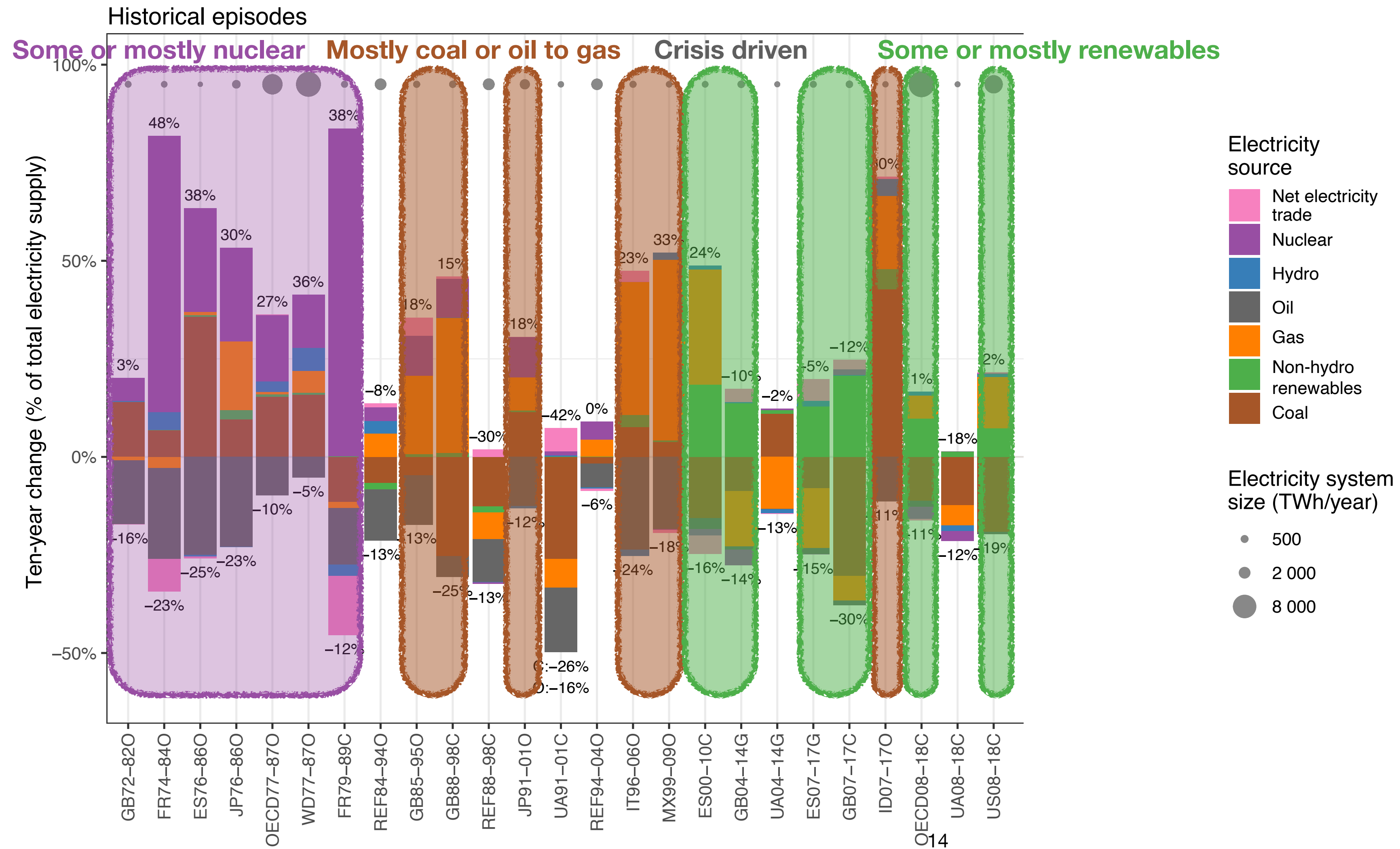
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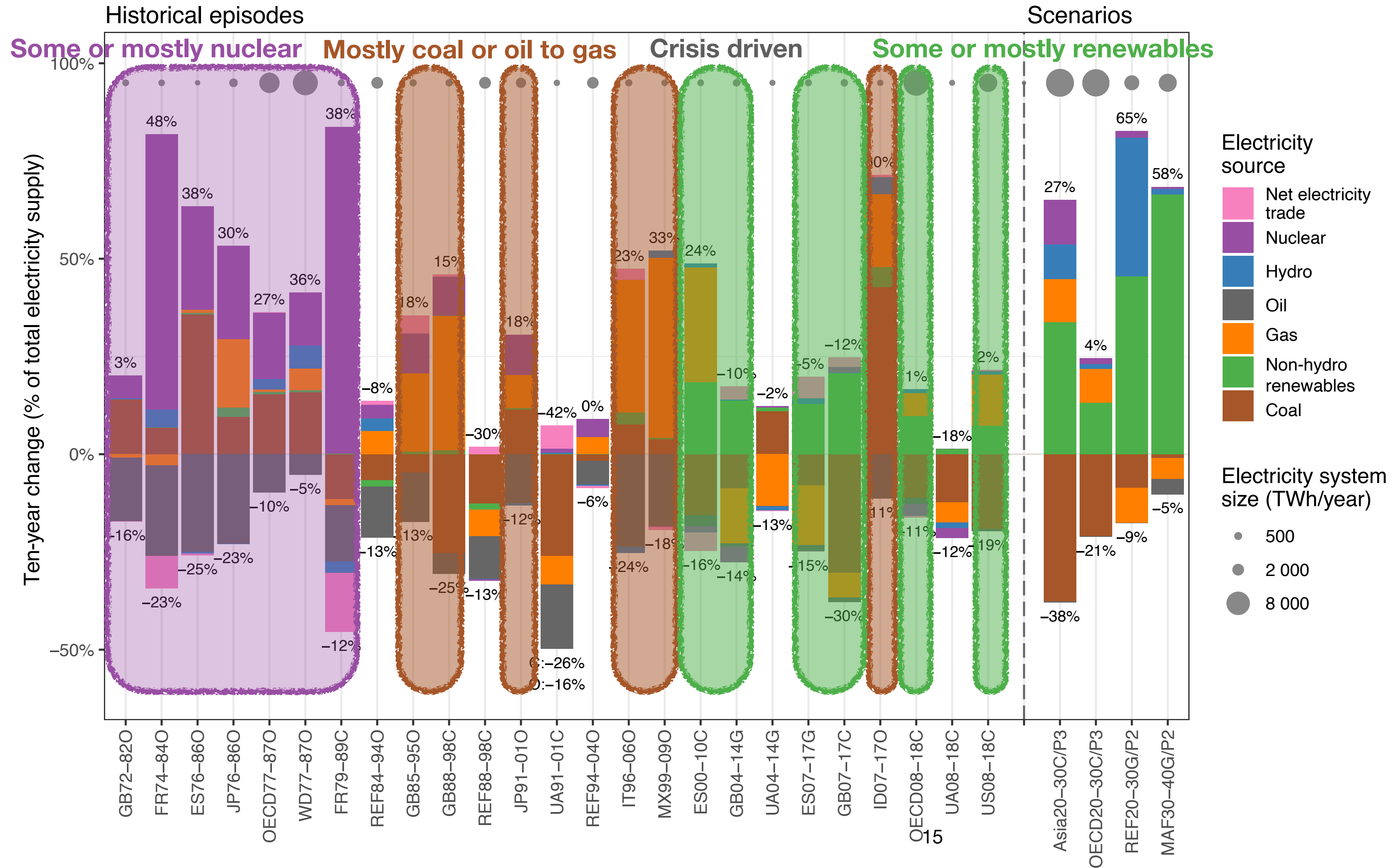
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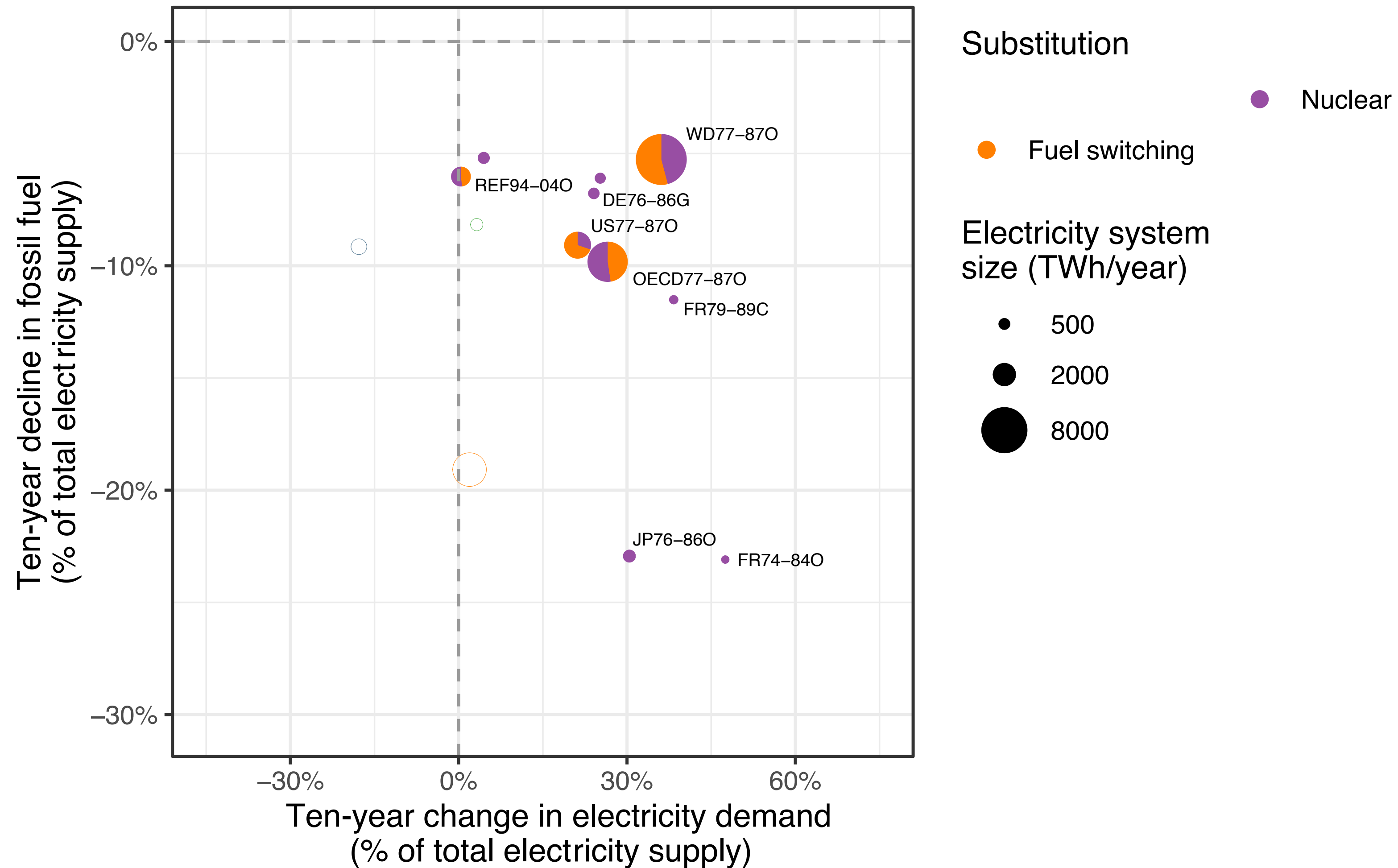
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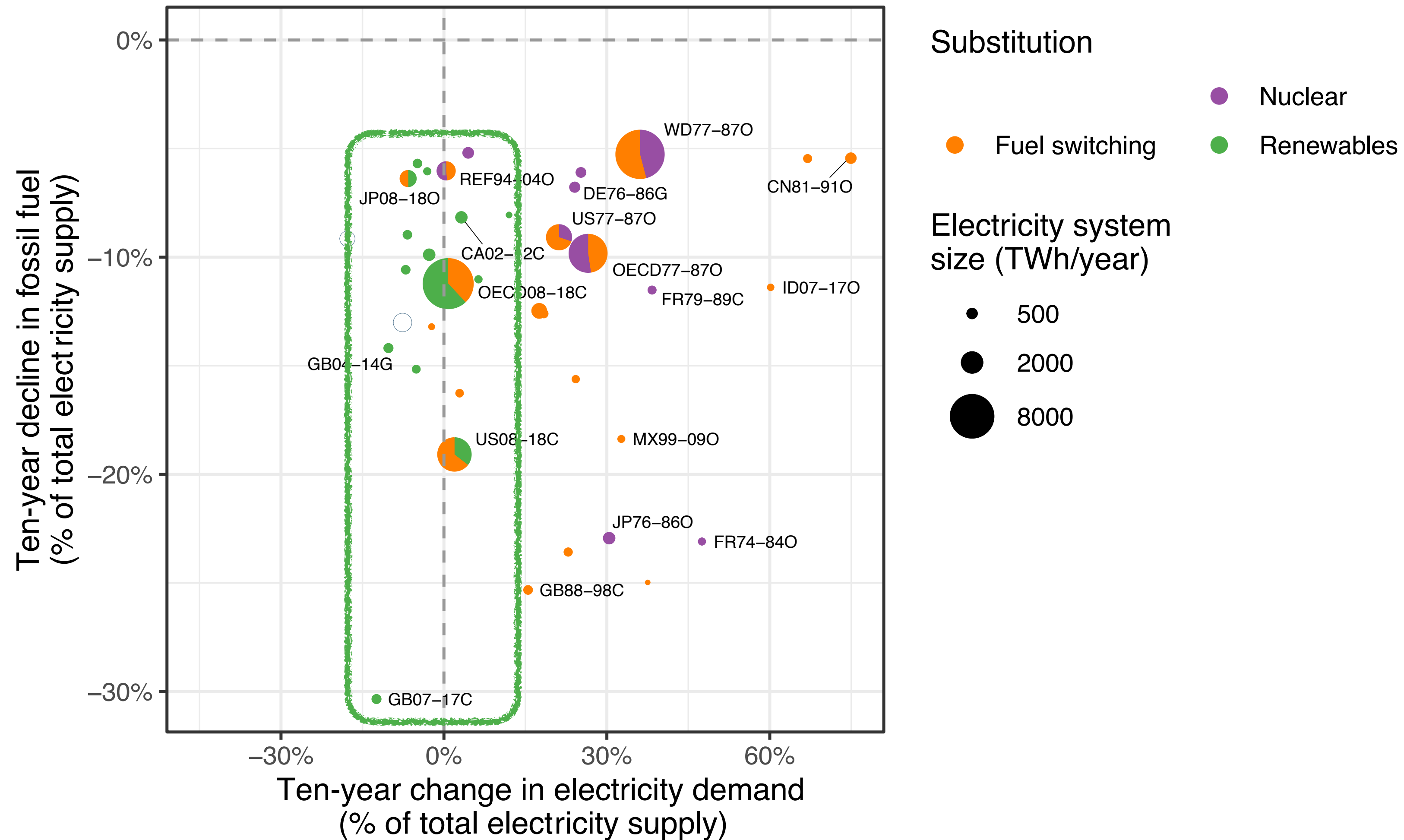


# Mapping feasibility zones for fossil fuel decline

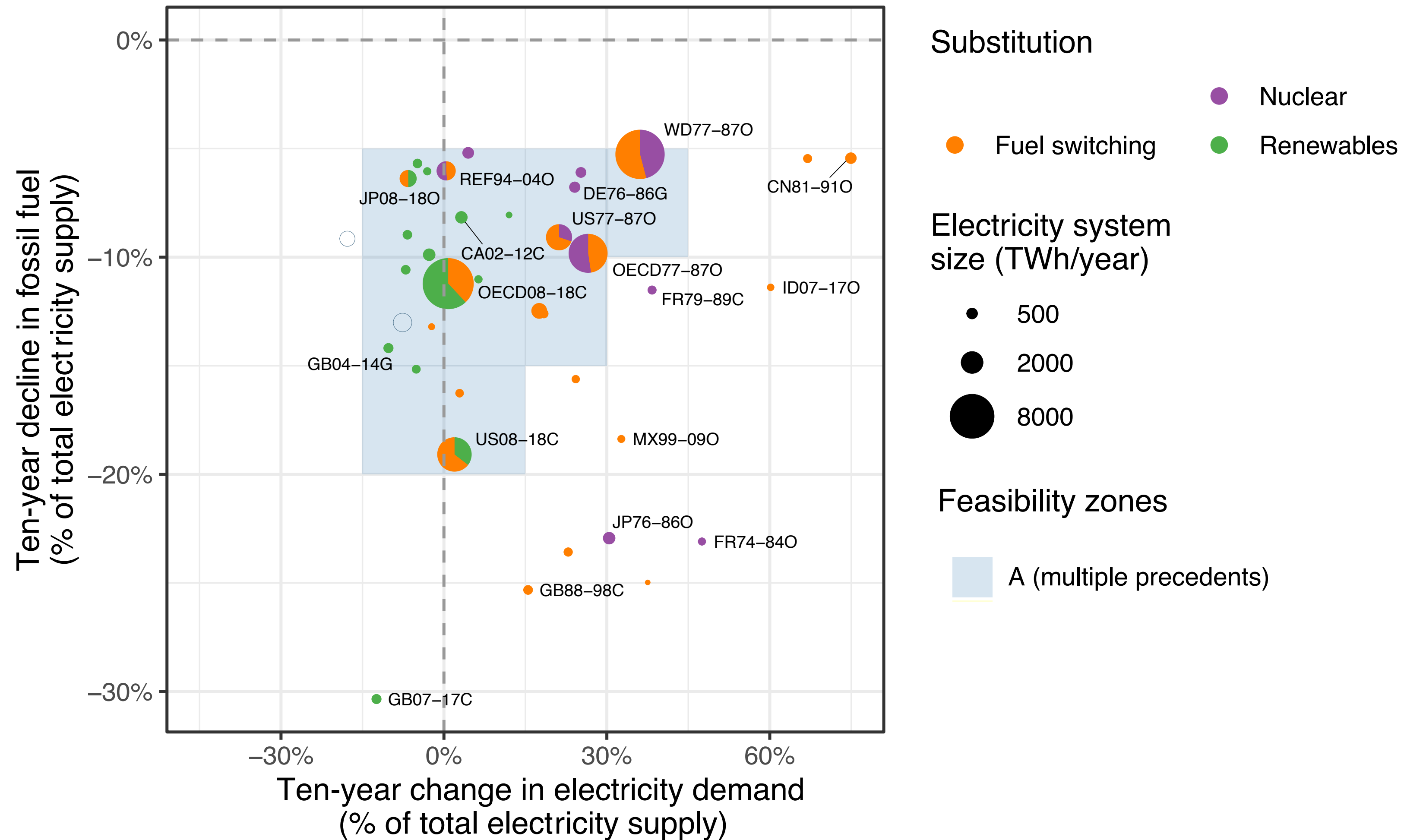




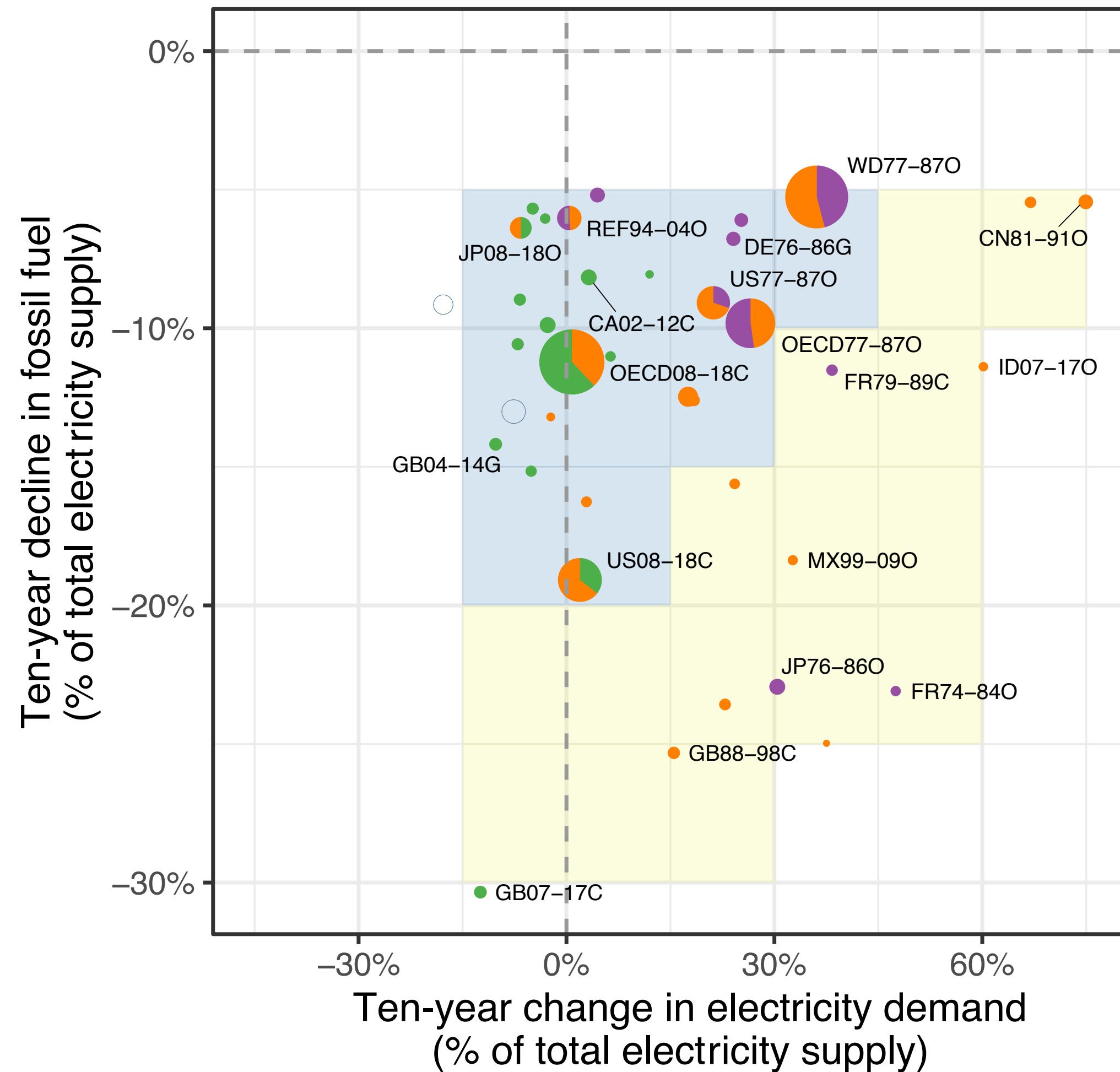
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# Mapping feasibility zones for fossil fuel decline



## Substitution

- Nuclear
- Fuel switching
- Renewables

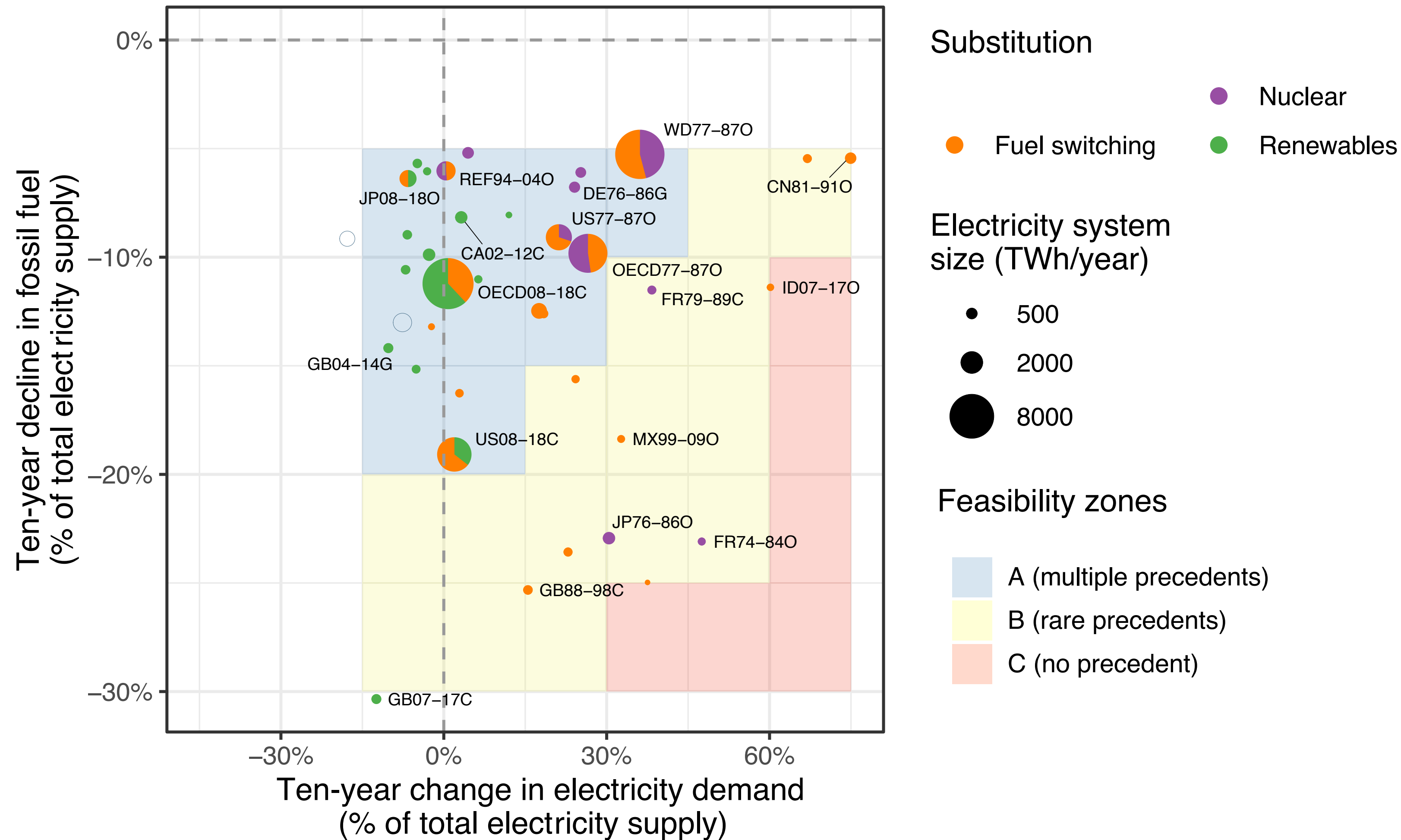
## Electricity system size (TWh/year)

- 500
- 2000
- 8000

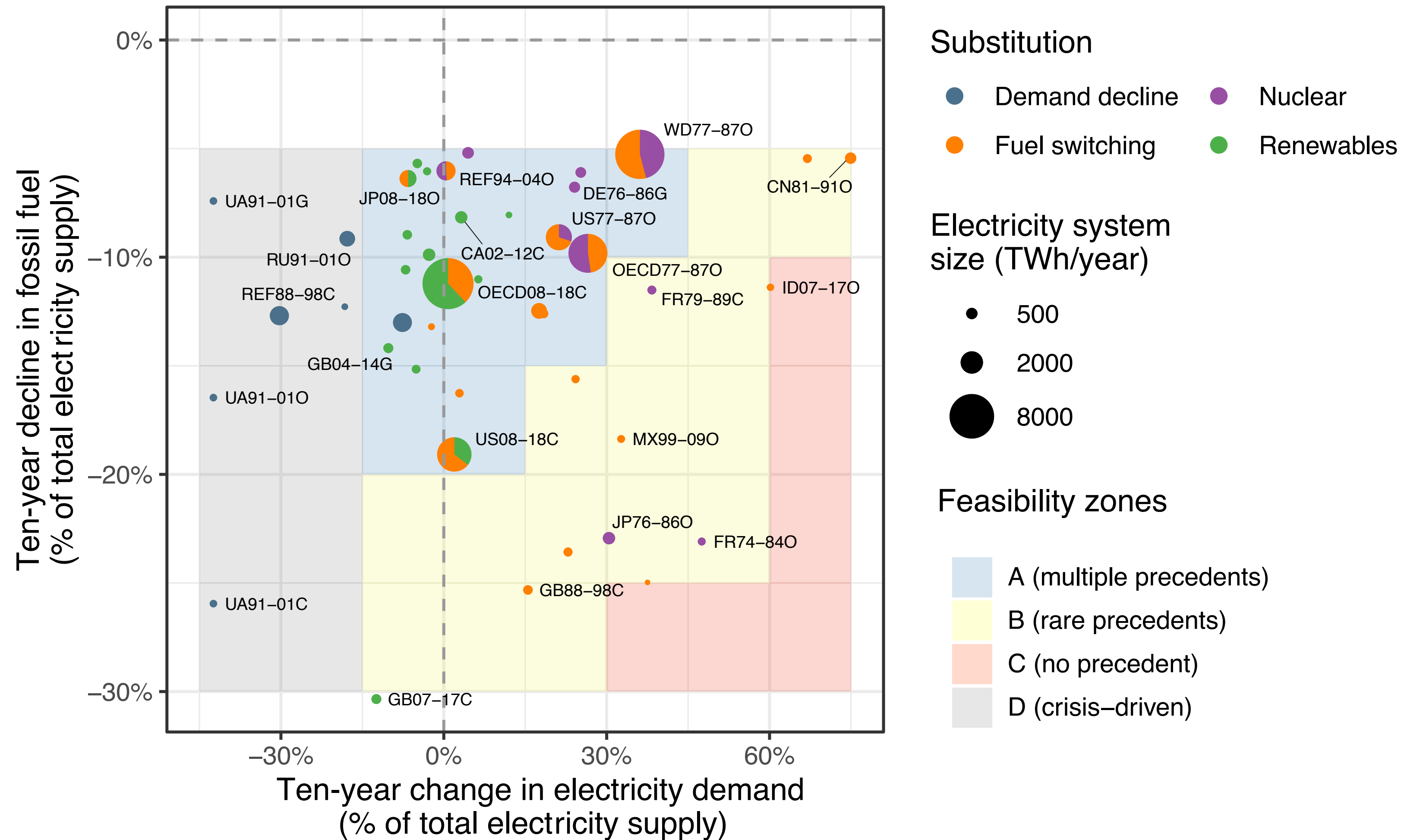
## Feasibility zones

- A (multiple precedents)
- B (rare precedents)

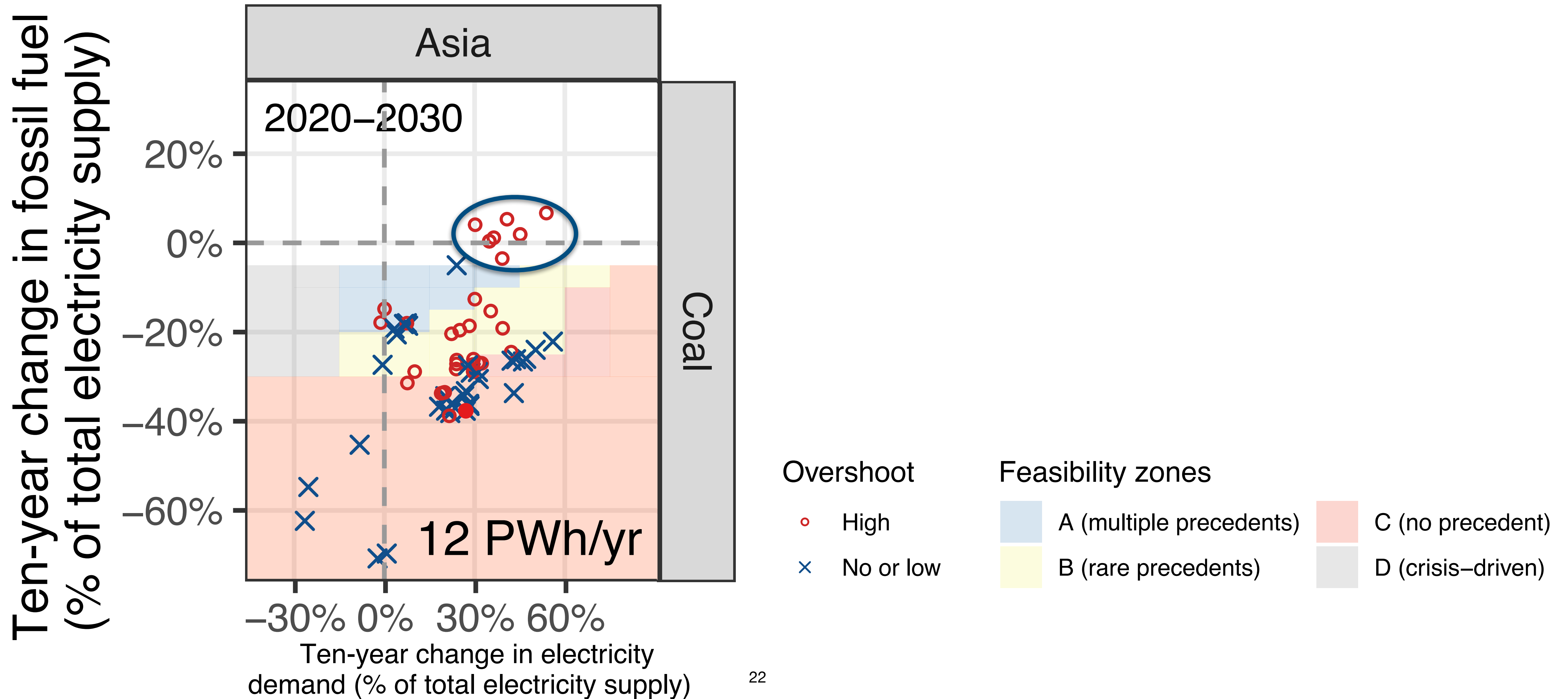
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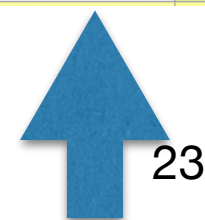
# Using feasibility zones to analyze future scenarios



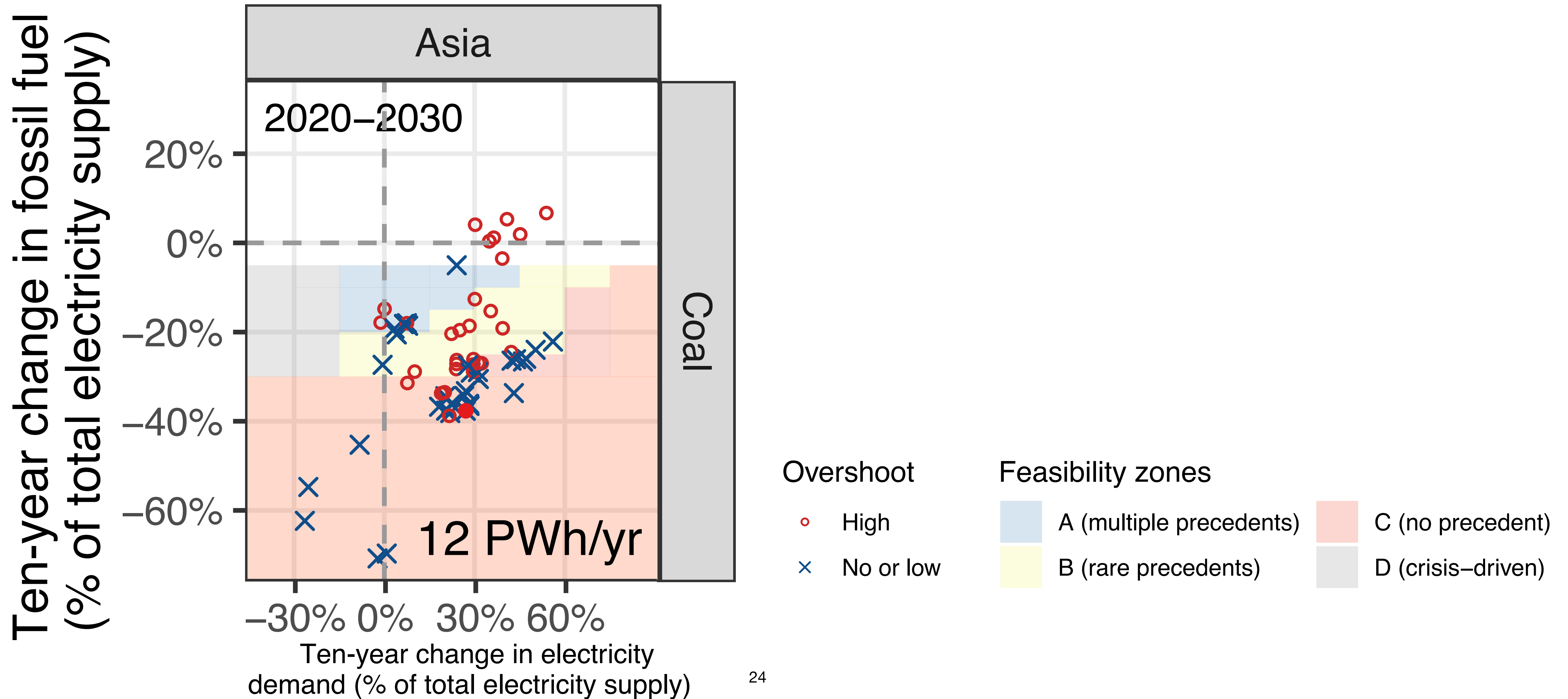
# A heatmap for each pathway to identify bottlenecks



Model	Scenario	Overshoot	Coal/Asia	Coal/Asia	Coal/Asia	Coa/Asia	Coal/OECD	Gas/MAF	Gas/REF	All
			2020-30	2030-40	2040-50					
IMAGE 3.0.1	IMA15-LiStCh	No or low	A	B		B (30-40)	A (20-30)		A (40-50)	B
IMAGE 3.0.1	IMA15-LoNCO2	High	A	B		B (30-40)	A (20-30)		A (40-50)	B
IMAGE 3.0.1	IMA15-Pop	No or low	A	B		B (30-40)	A (20-30)		A (40-50)	B
IMAGE 3.0.1	IMA15-RenElec	High	B	A		B (20-30)	B (20-30)		A (40-50)	B
IMAGE 3.0.1	IMA15-TOT	No or low	B	B		B (20-30)	A (20-30)		A (20-30)	B
IMAGE 3.0.1	SSP1-19	No or low	B	A		B (20-30)	D (20-30)		B (40-50)	D
MERGE-ETL 6.0	DAC15_50	No or low	C			C (20-30)	B (20-30)	C (30-40)	B (20-30)	C
MESSAGE-GLOBIOM 1.0	ADVANCE_2020_1.5C-2100	No or low	C			C (20-30)	A (20-30)		C (20-30)	C
MESSAGE-GLOBIOM 1.0	ADVANCE_2030_Price1.5C	High		C		C (30-40)	A (20-30)	B (30-40)	C (30-40)	C
MESSAGE-GLOBIOM 1.0	EMF33_1.5C_cost100	No or low	C			C (20-30)	B (20-30)		C (20-30)	C
MESSAGE-GLOBIOM 1.0	EMF33_1.5C_full	No or low	C			C (20-30)	B (20-30)		C (20-30)	C
MESSAGE-GLOBIOM 1.0	EMF33_WB2C_cost100	High	B	A		B (20-30)	B (20-30)		A (40-50)	B
MESSAGE-GLOBIOM 1.0	EMF33_WB2C_full	High	B	B		B (20-30)	A (20-30)		A (40-50)	B
MESSAGE-GLOBIOM 1.0	EMF33_WB2C_limbio	High	C			C (20-30)	B (20-30)		A (40-50)	C
MESSAGE-GLOBIOM 1.0	EMF33_WB2C_nofuel	High	B	A		B (20-30)	B (20-30)			B
MESSAGE-GLOBIOM 1.0	SSP1-19	No or low	C	A		C (20-30)	B (20-30)			C
MESSAGE-GLOBIOM 1.0	SSP2-19	No or low	C			C (20-30)	B (20-30)		B (30-40)	C
MESSAGEix-GLOBIOM 1.0	CD-LINKS_NPi2020_400	High	B			B (20-30)	A (20-30)		A (40-50)	B
POLES ADVANCE	ADVANCE_2020_1.5C-2100	No or low	C	A		C (20-30)	A (20-30)	A (30-40)	A (30-40)	C
POLES ADVANCE	ADVANCE_2020_WB2C	High	B	A		B (20-30)	A (20-30)		A (30-40)	B
POLES ADVANCE	ADVANCE_2030_1.5C-2100	High		C		C (30-40)	A (30-40)	B (30-40)	D (30-40)	C
POLES ADVANCE	ADVANCE_2030_Price1.5C	High		C		C (30-40)	A (30-40)	B (30-40)	D (30-40)	C
POLES ADVANCE	ADVANCE_2030_WB2C	High		B		B (30-40)	A (20-30)	A (30-40)	A (30-40)	B
REMIND 1.7	ADVANCE_2020_1.5C-2100	High	C	B		C (20-30)	B (20-30)	C (30-40)	C (20-30)	C
REMIND 1.7	ADVANCE_2030_1.5C-2100	High		B	A	B (30-40)	B (20-30)	C (40-50)	C (30-40)	C
REMIND 1.7	ADVANCE_2030_Price1.5C	High		B	A	B (30-40)	B (20-30)	C (40-50)	C (30-40)	C

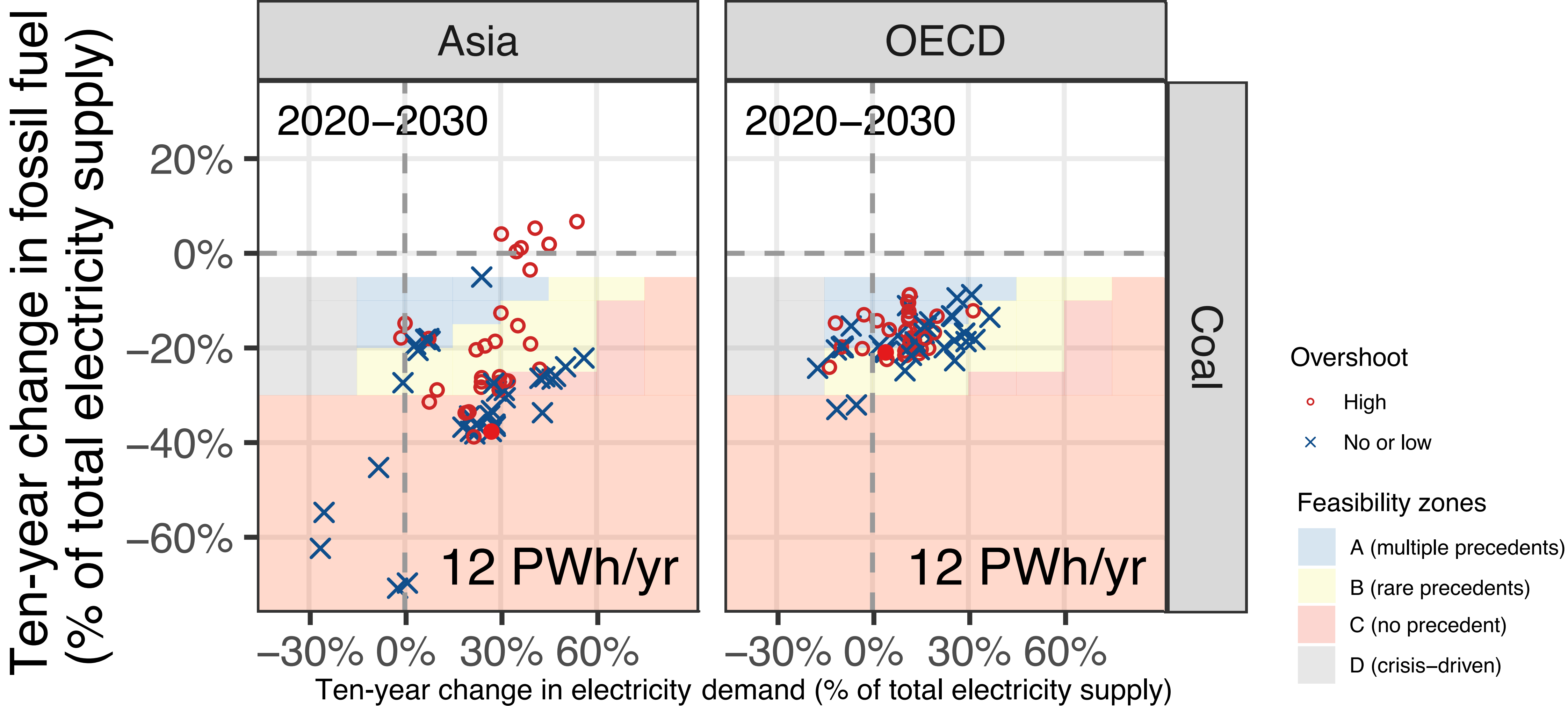


# Using feasibility zones to analyze future scenarios

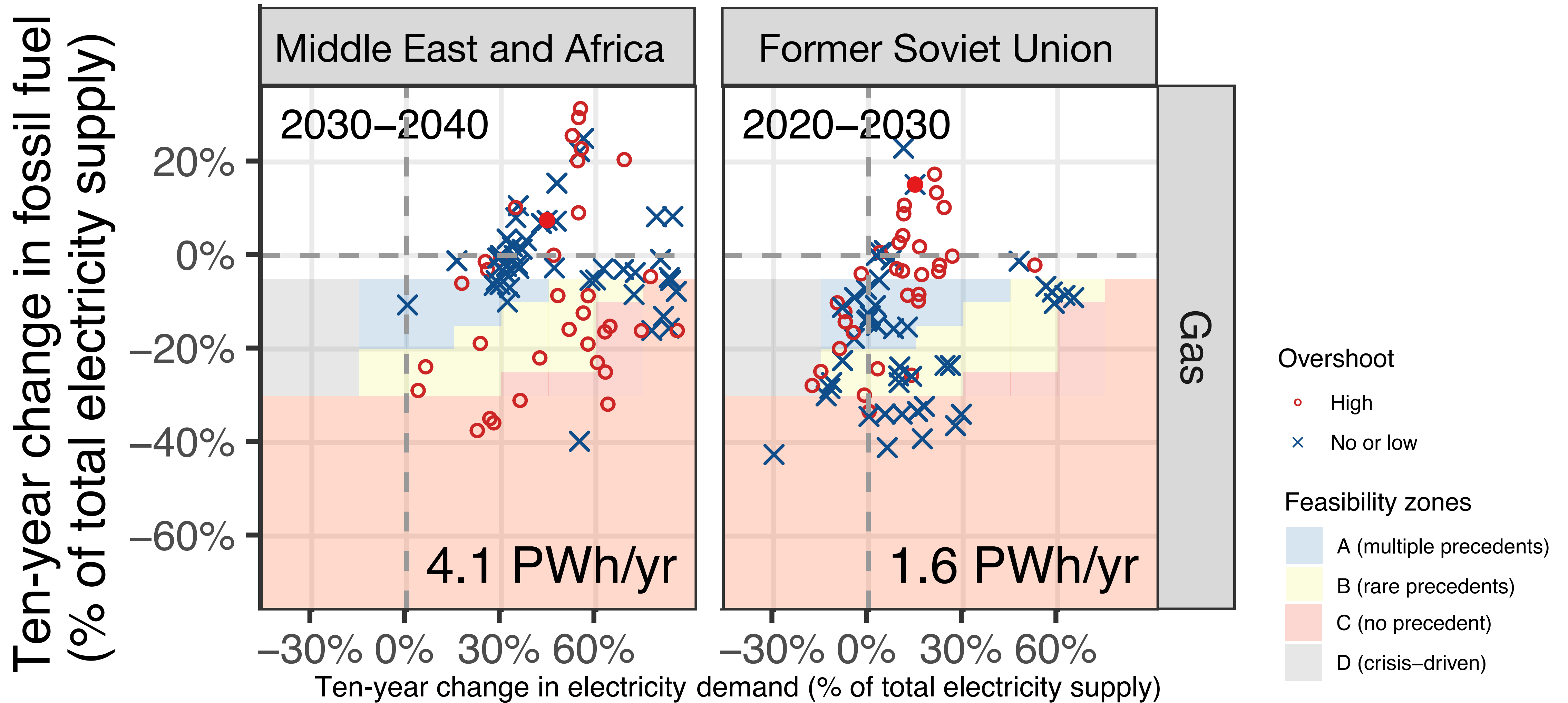




# Using feasibility zones to analyze future scenarios



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# Conclusions

- Methodological innovations in feasibility assessment
  - examine **global** and macro-region feasibility in light of **national** precedents
  - include **context** (e.g. country size, demand growth, availability of substitute technologies) in feasibility analysis
  - shift from binary to probabilistic feasibility analysis using **feasibility zones** and **heatmaps**
- There are fewer precedents of rapid fossil decline in larger countries and under fast demand growth
- There are more precedents of rapid fossil fuel decline in the 20th century, when coal/oil were substituted by nuclear and natural gas
- The decline of coal in Asia and OECD and natural gas in the Middle East and the Reforming Economies is the most unprecedented in climate scenarios