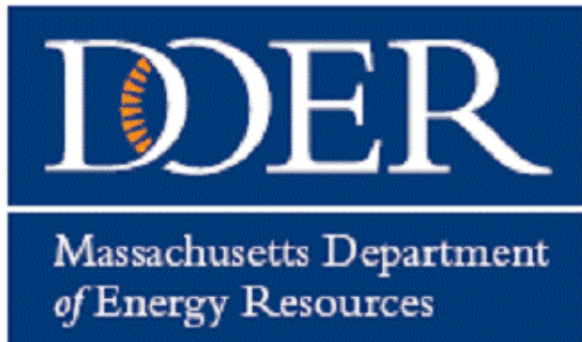
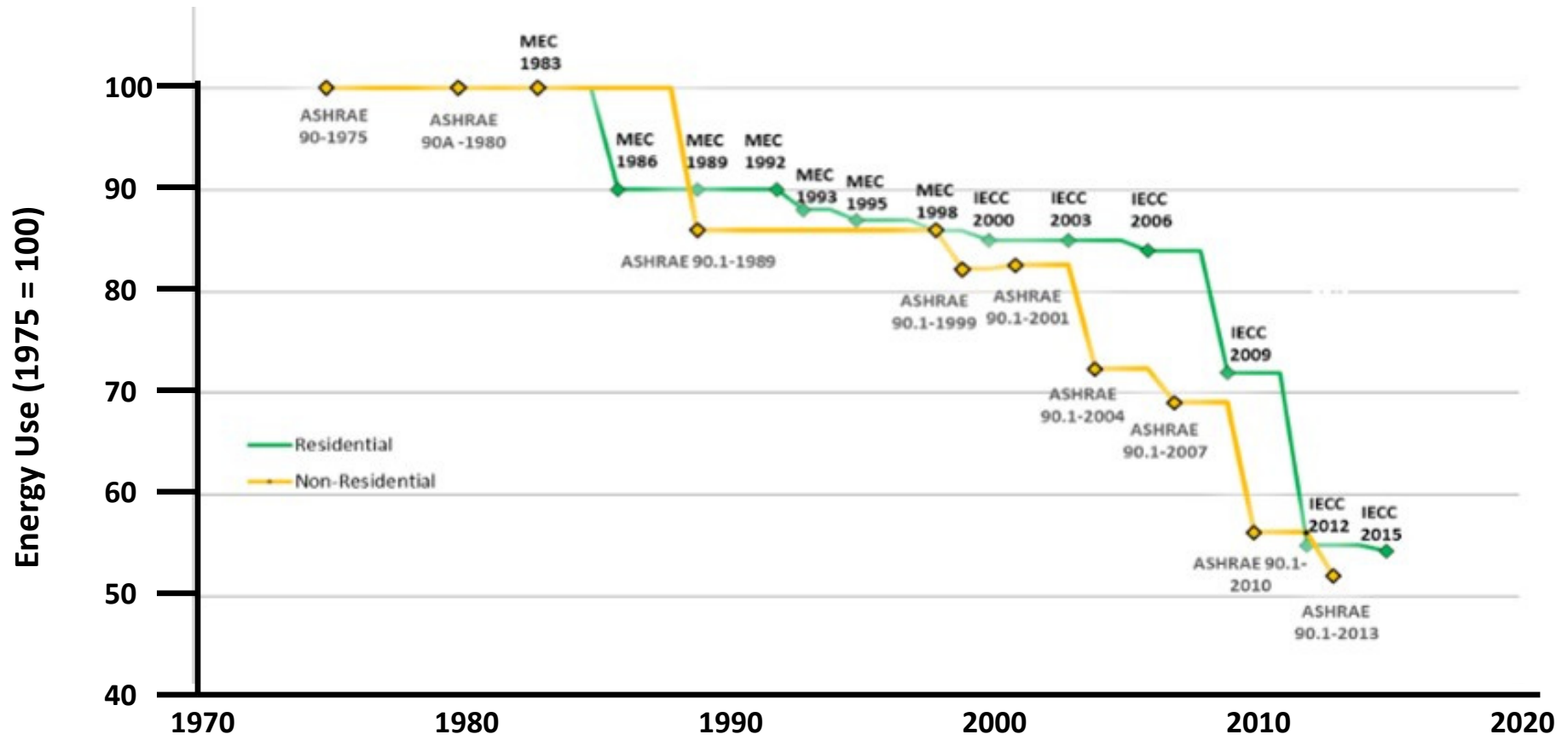
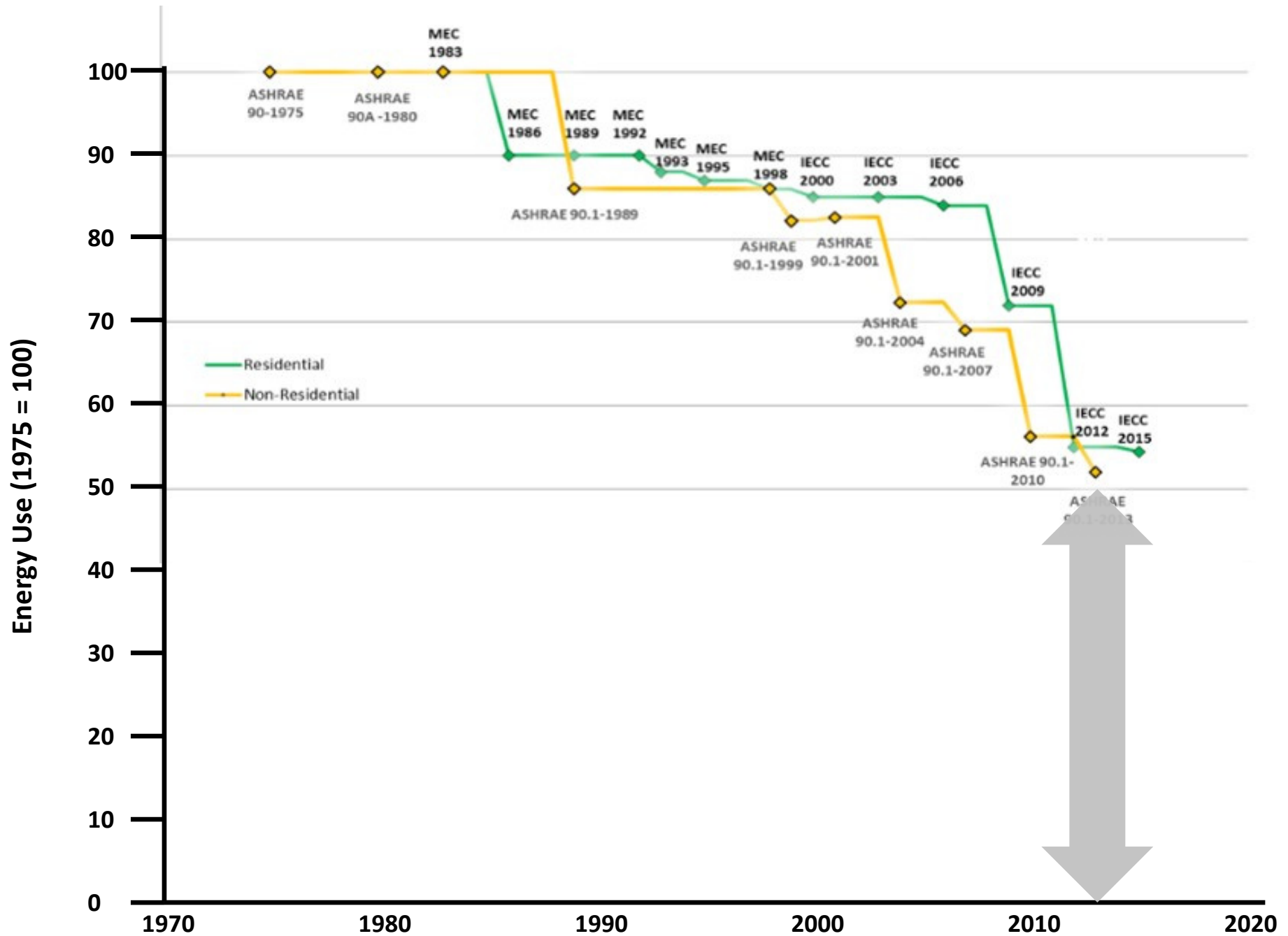


THE RACE TOWARDS CARBON NEUTRALITY: DRIVERS AND BARRIERS

March 14 , 2019









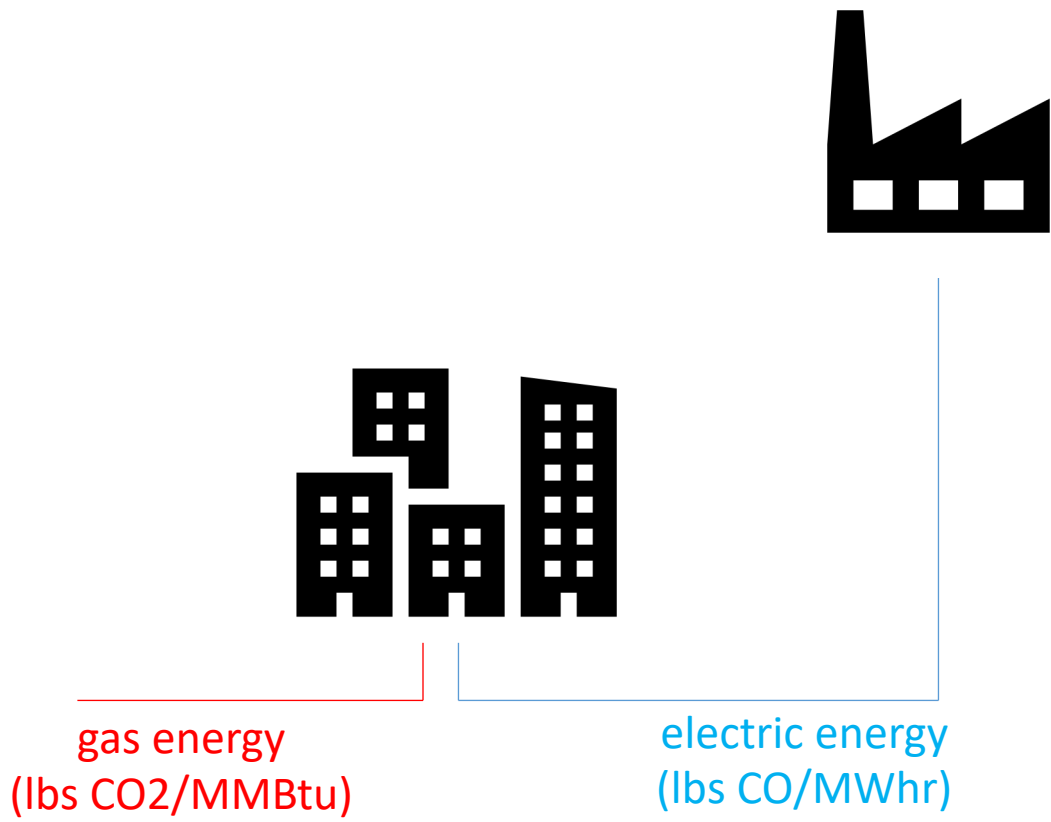
electric energy

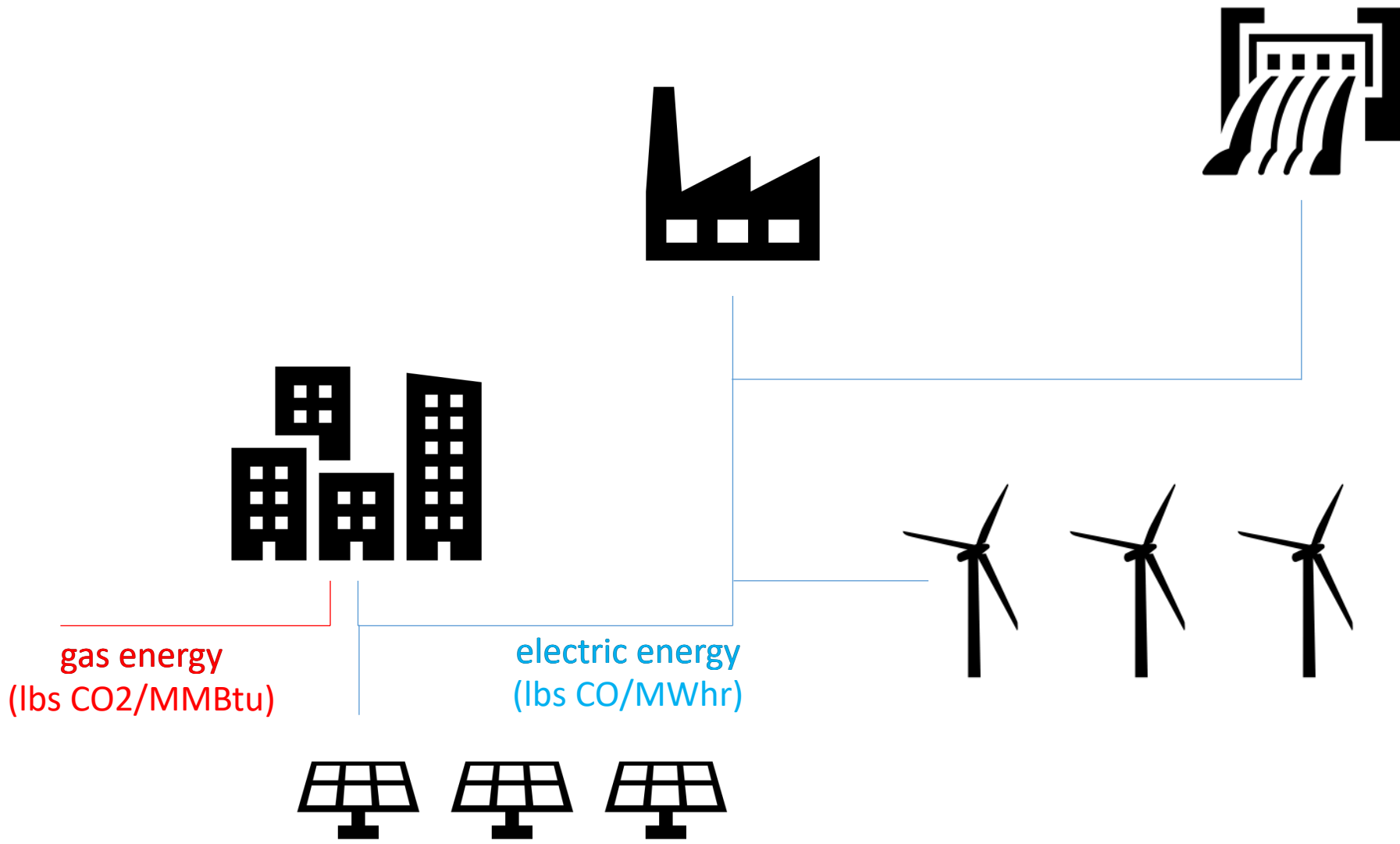


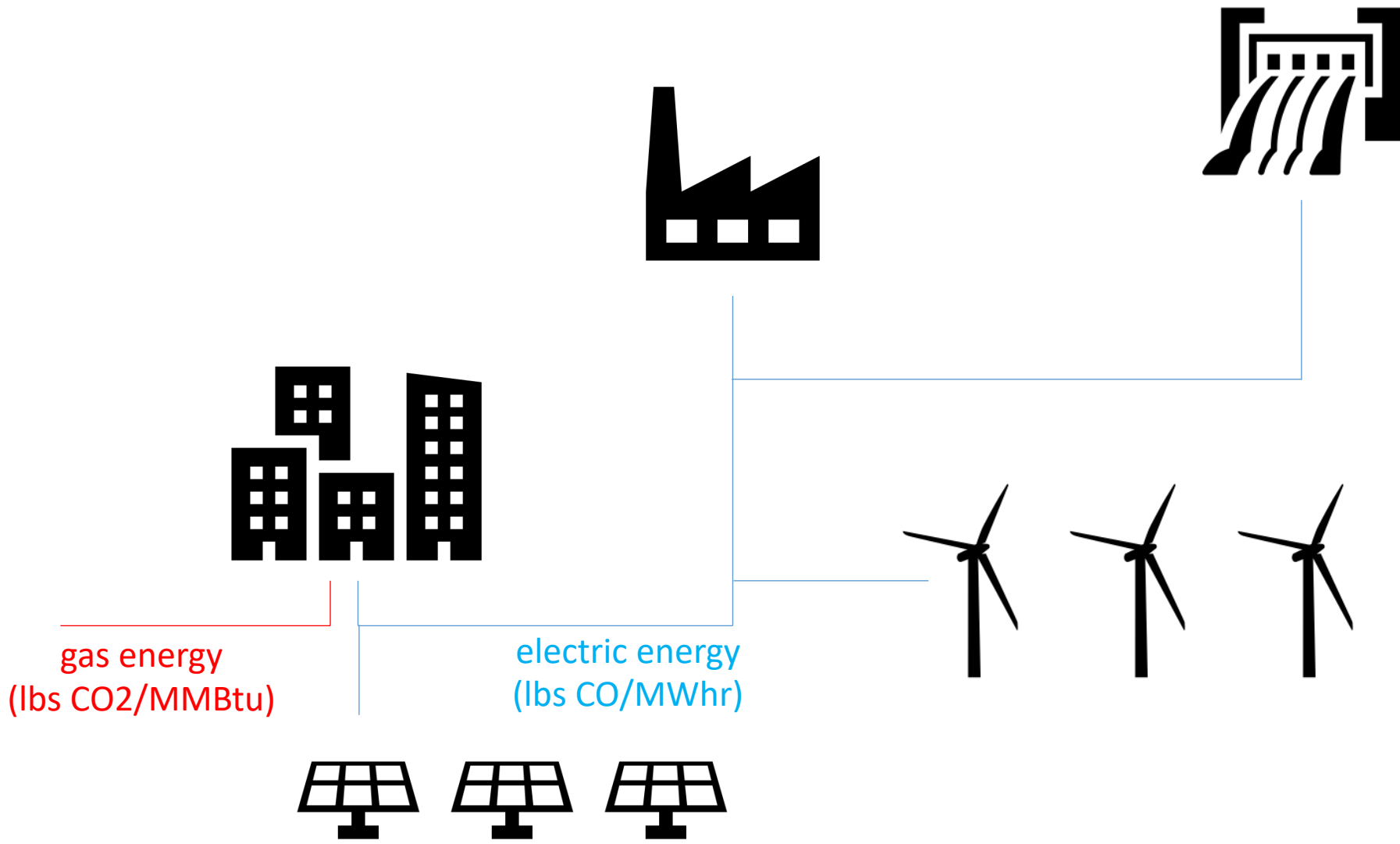
gas energy

Last 50 years of Code:

all saved energy (saved BTUs)
are the same

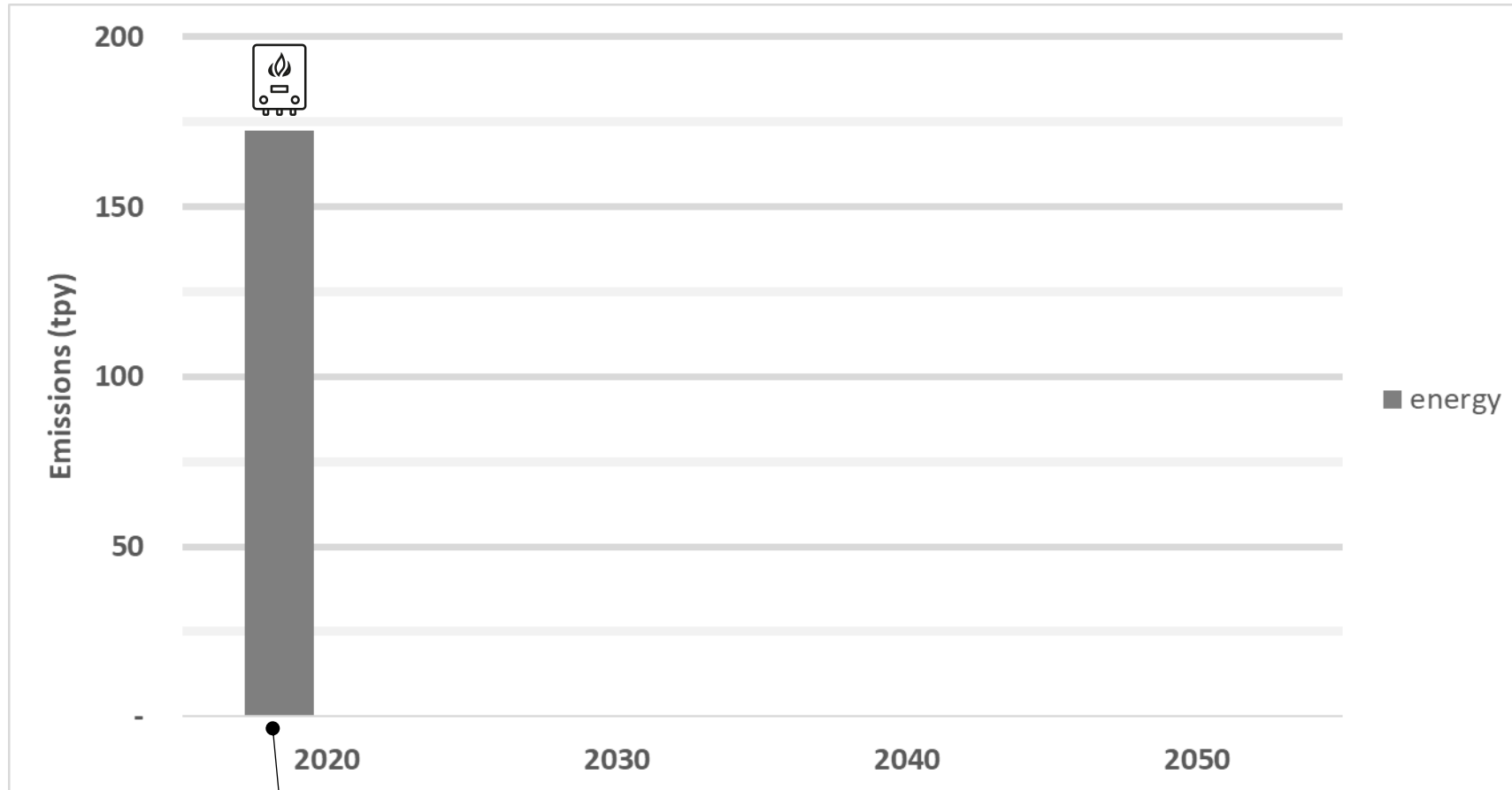






Year	Emission Rate (lbs CO2/MW hr)
2020	700
2030	600
2040	400
2050	200

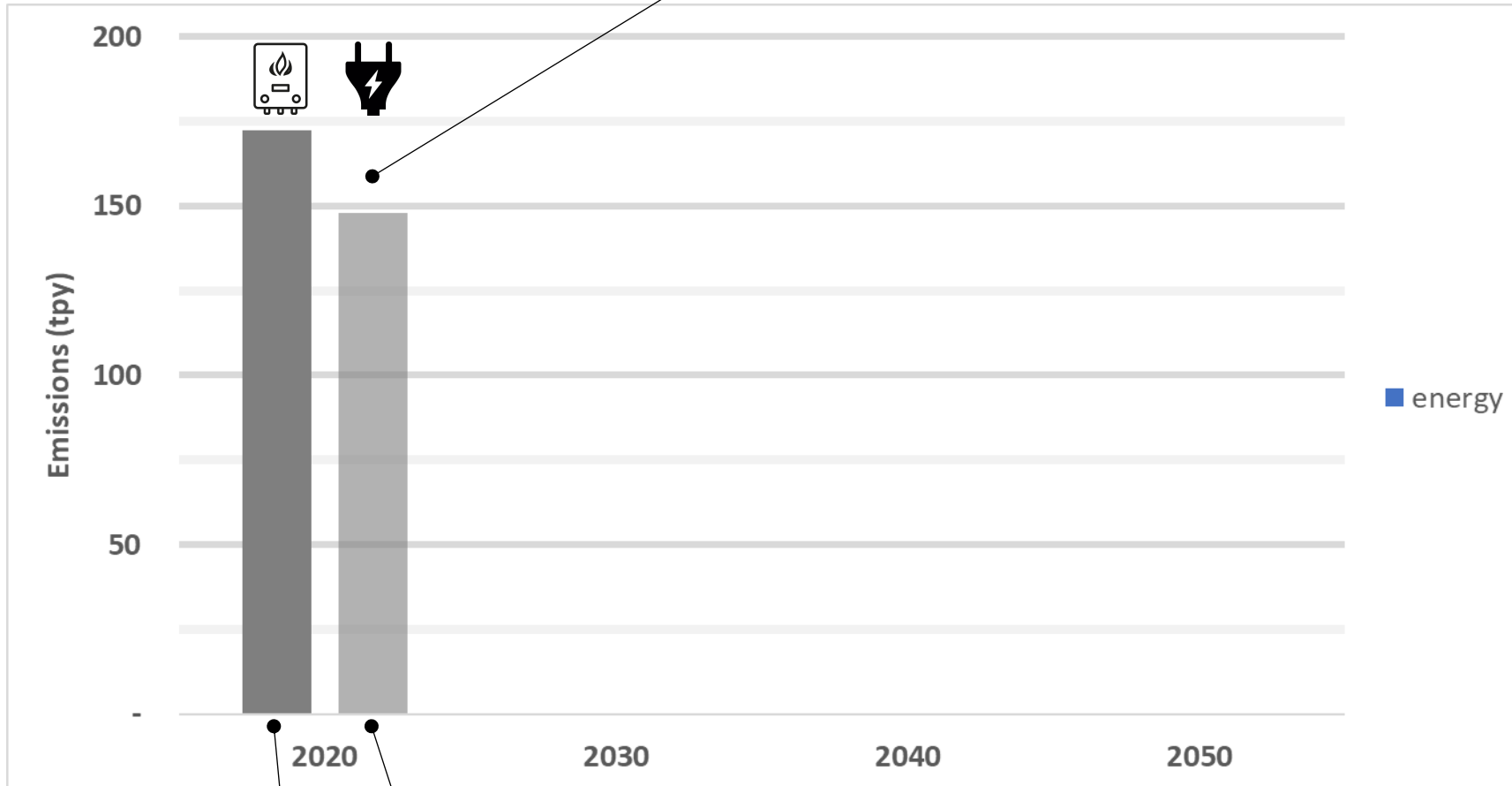
50,000-sf multifamily



Typically better-than-Code building with **gas heat and hot water**

50,000-sf multifamily

14% improvement

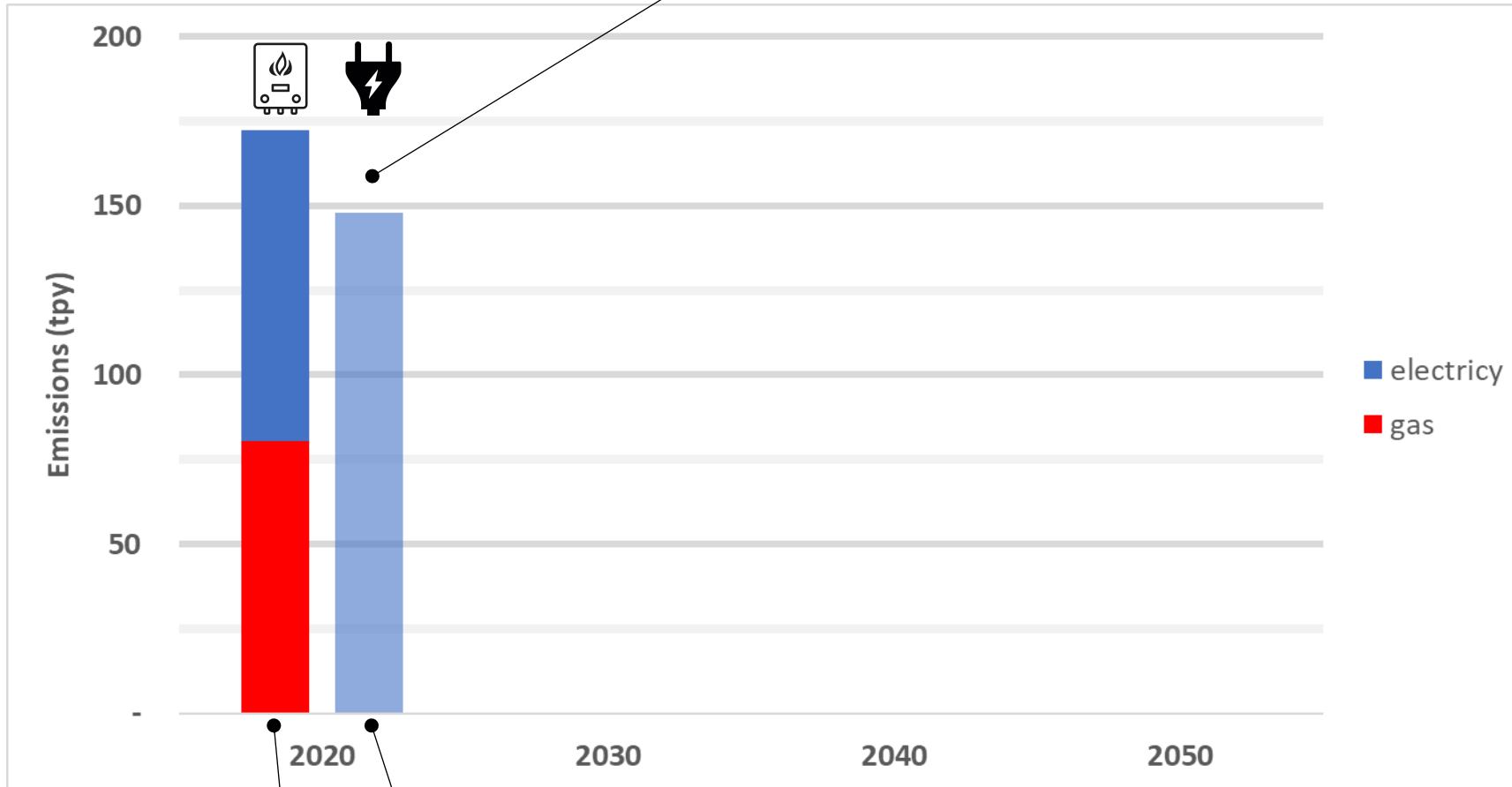


Typical better-than-Code building with **gas heat and hot water**

Swapping gas heat and hot water with **electric heat pump heat and hot water**

50,000-sf multifamily

14% improvement

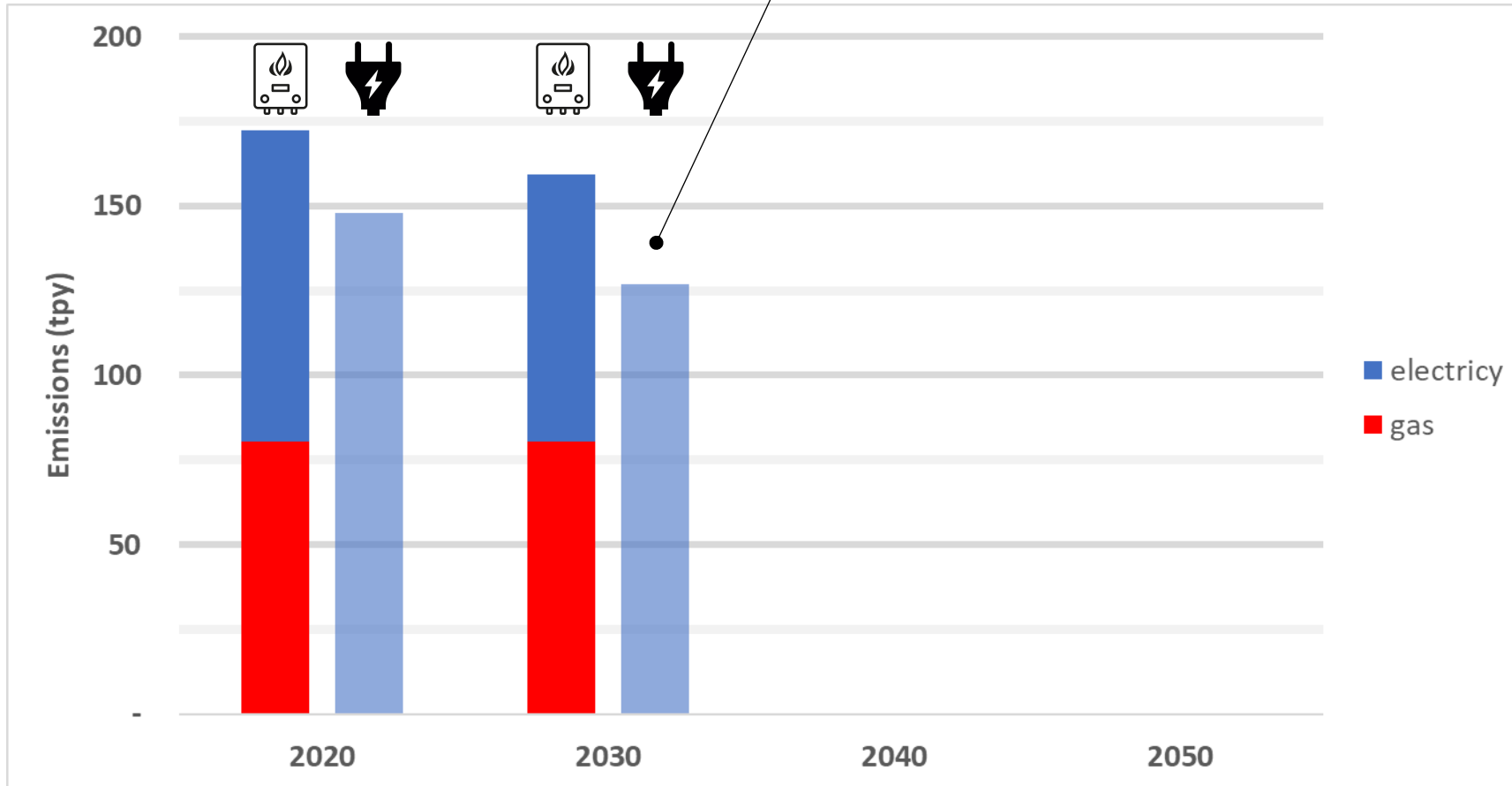


Typical better-than-Code building with **gas heat and hot water**

Swapping gas heat and hot water with **electric heat pump heat and hot water**

50,000-sf multifamily

20% improvement



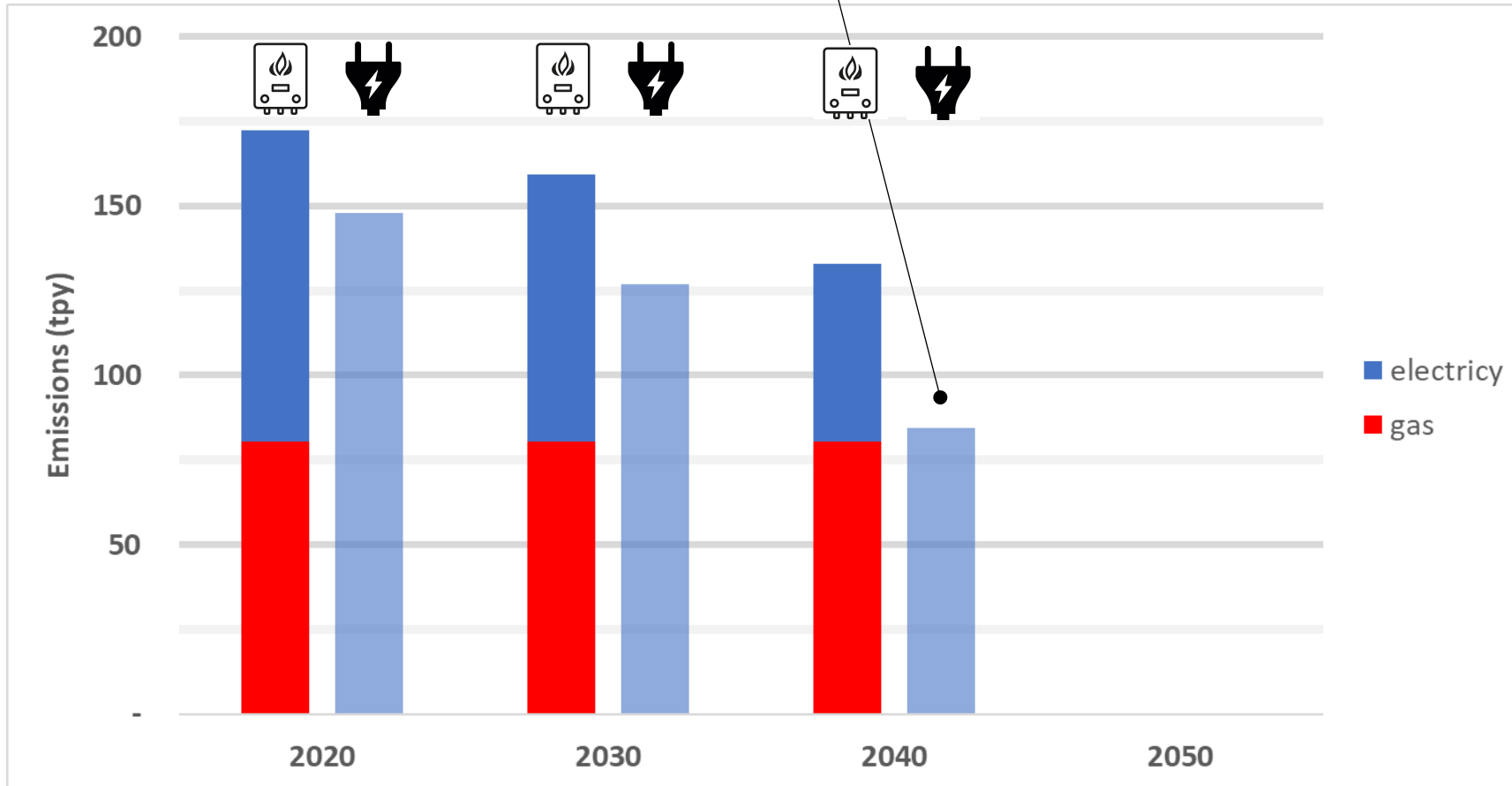
Electric Emission Rate
(Lbs CO2/ Mwhr)

700

600

50,000-sf multifamily

36% improvement



Electric Emission Rate
(Lbs CO2/ Mwhr)

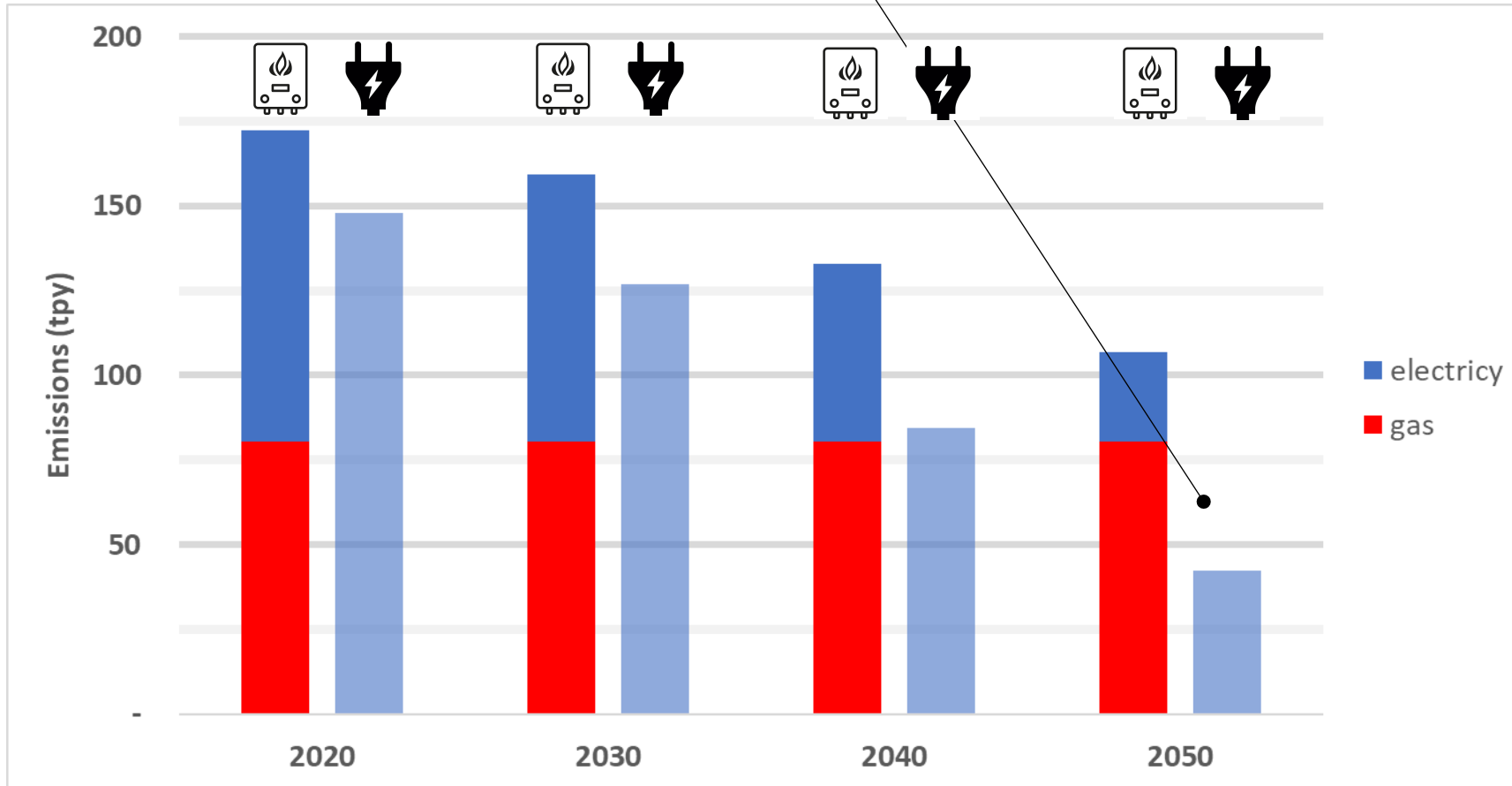
700

600

400

50,000-sf multifamily

60% improvement



Electric Emission Rate
(Lbs CO2/ Mwhr)

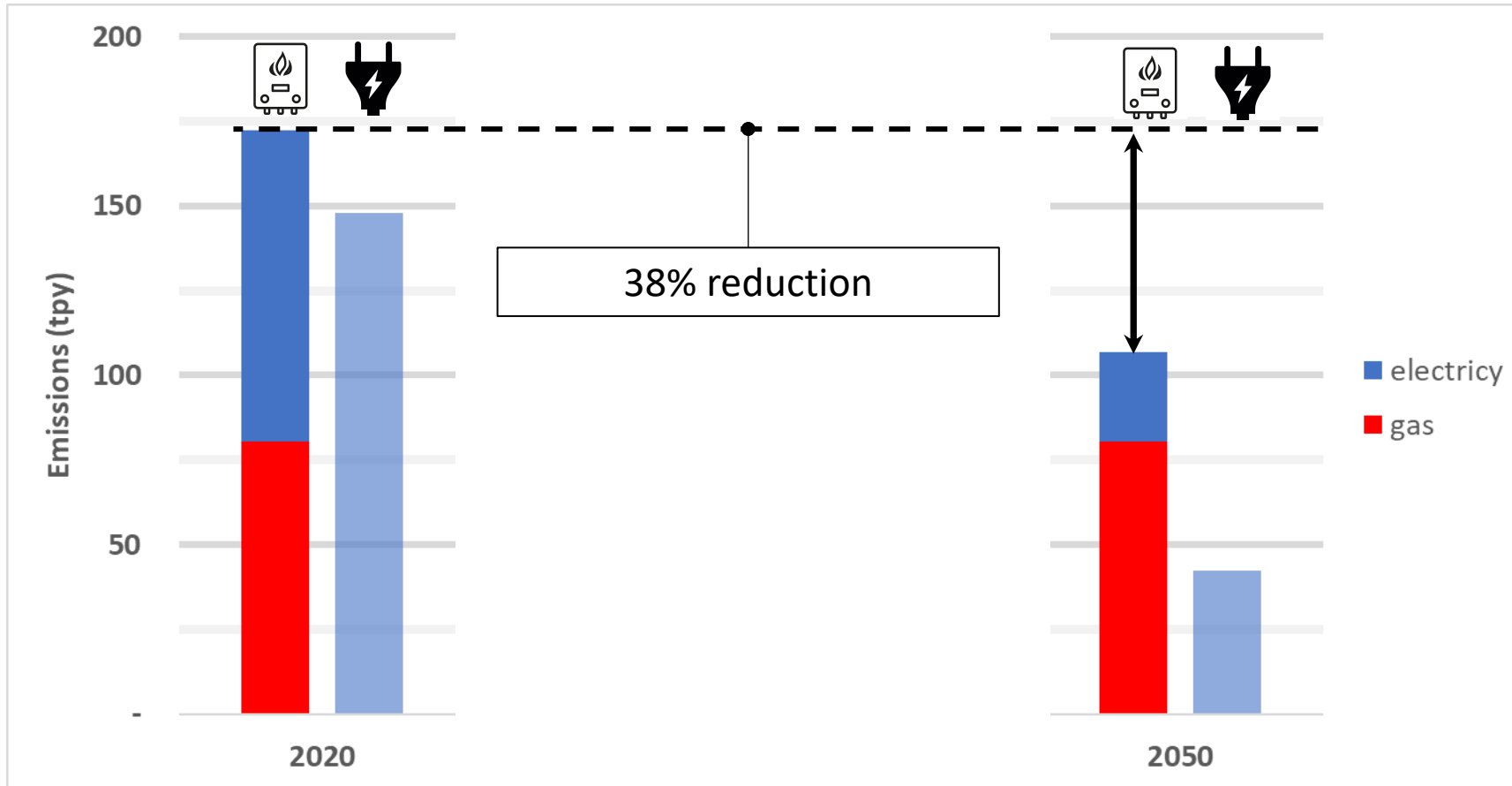
700

600

400

200

50,000-sf multifamily



Electric Emission Rate
(Lbs CO2/ Mwhr)

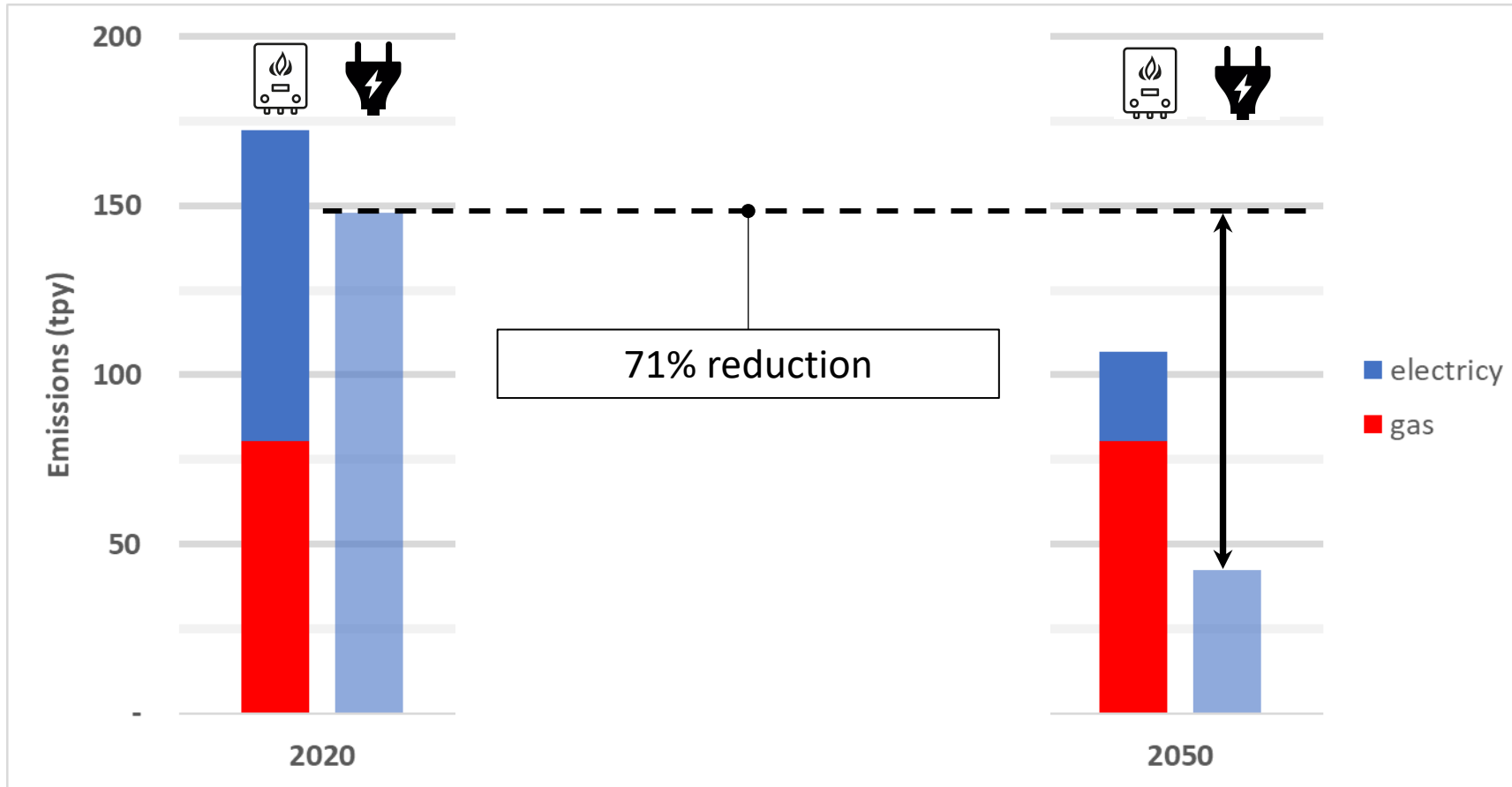
700

600

400

200

50,000-sf multifamily



Electric Emission Rate
(Lbs CO2/ Mwhr)

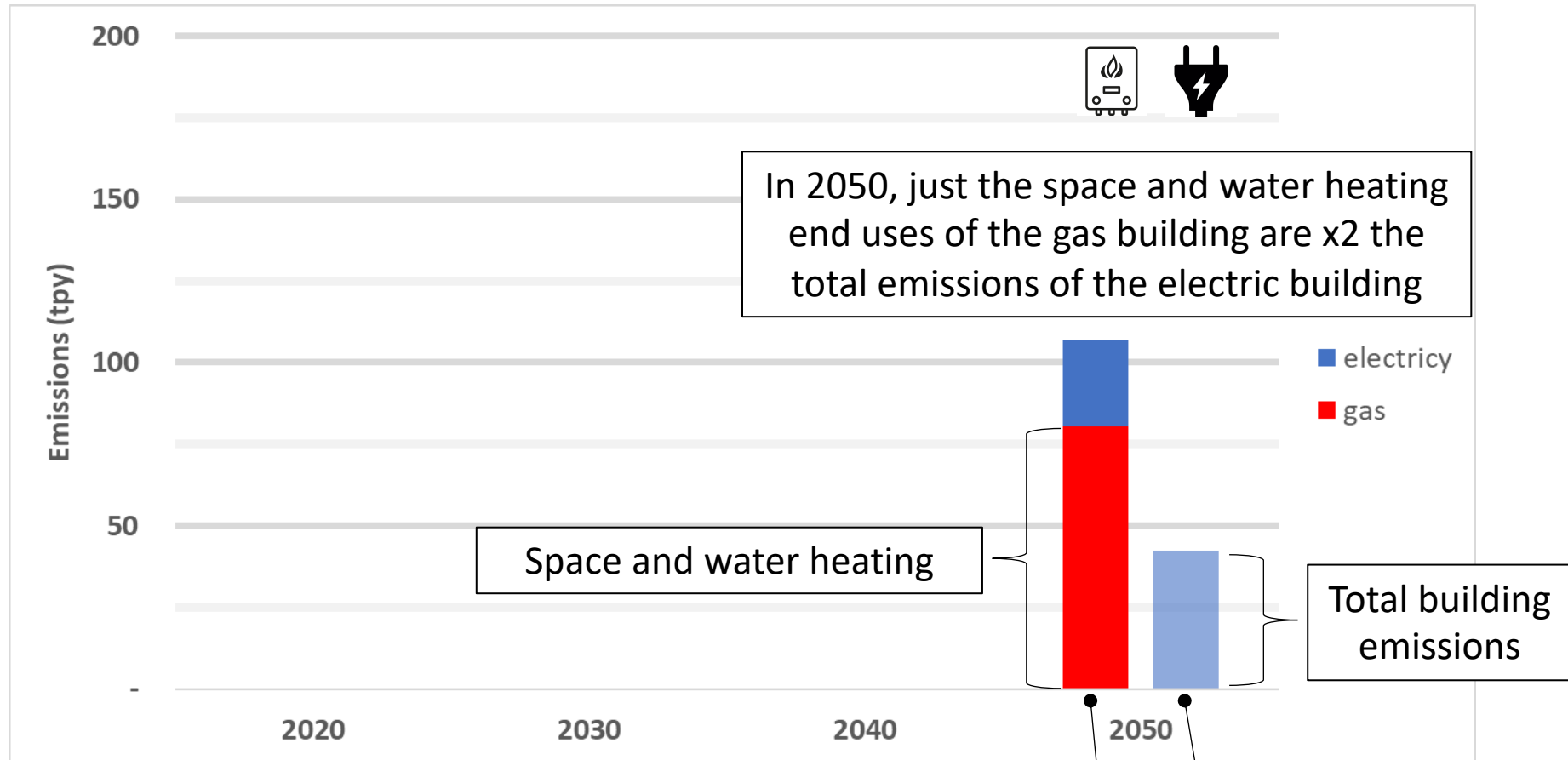
700

600

400

200

50,000-sf multifamily



Space and water heating



Total building emissions

Typical better-than-Code building with **gas heat and hot water**

Swapping gas heat and hot water with **electric heat pump heat and hot water**

50,000-sf multifamily



\$1/therm
\$0.20/kWhr

Annual Cost	 Space heating and hot water with Gas	 Space heating and hot water with electric heat pumps
Gas	\$14,000	\$0
Electricity	\$52,000	\$85,000
Total	\$66,000	\$85,000

least cost

50,000-sf multifamily

\$1.50/therm
\$0.20/kWhr

Annual Cost	 Space heating and hot water with Gas	 Space heating and hot water with electric heat pumps
Gas	\$21,000	\$0
Electricity	\$52,000	\$85,000
Total	\$73,000	\$85,000



least cost


50,000-sf multifamily

\$1.50/therm
\$0.20/kWhr

Peak space heating:
12.4 btu/hr-sf

Peak space heating:
4.4 btu/hr-sf

Annual Cost	 Space heating and hot water with Gas	 Space heating and hot water with electric heat pumps
Gas	\$21,000	\$0
Electricity	\$52,000	\$85,000
Total	\$73,000	\$85,000

 + PH Space heating and hot water with electric heat pumps and Passivehouse
\$0
\$64,000
\$64,000

least cost

ENABLING STEPS

- Envelope
- Air tightness
- *Peak heat limit?*
- *Total heat limit?*

**ELECTRIFICATION
OF HEATING**

Idea

Implementation into Code

Not all Btus are the same

- Emissions basis, not Btu basis
- Recognize future grid emission rates

Electrify space and water heating

- Heat pump space heating
- Heat pump water heating

Enabling Steps to Electrify

- Heating peak limits (btu/sf-hr); total heat limits (btu/sf-yr)
- Envelope backstop