SIEMENS

Using the City Performance Tool (CyPT) to Test City Sustainability Targets

Minneapolis: 80 by 50?

Executive Summary

It is possible for Minneapolis to achieve its 80 by 50 target, if the City, its utilities, and its inhabitants work aggressively to clean the local energy supply, adopt electric transport and public transit, and improve energy efficiency in buildings.

Executive Summary

- Xcel's new plan for 65% clean energy sources is a significant step in the direction of achieving ambitious sustainability goals for the City.

- But even with this step, Xcel will have to continue greening its electricity mix through to 2050, *and* 40 buildings and transportation technologies will have to be implemented and adopted at their highest implementation rates by 2050 to ensure that targets are met.

- Our results show that, if the electricity mix gets significantly cleaner, the top-performing technologies for reducing carbon emissions include 1) electrifying both passenger and freight road transport and 2) improving energy efficiency in buildings, particularly in commercial and government buildings.

- Additional benefits could be realized from public transit, if more people could be attracted to use it.

Using the CyPT in Minneapolis

CITY DATA + CITY TARGETS

73 TECHNOLOGIES

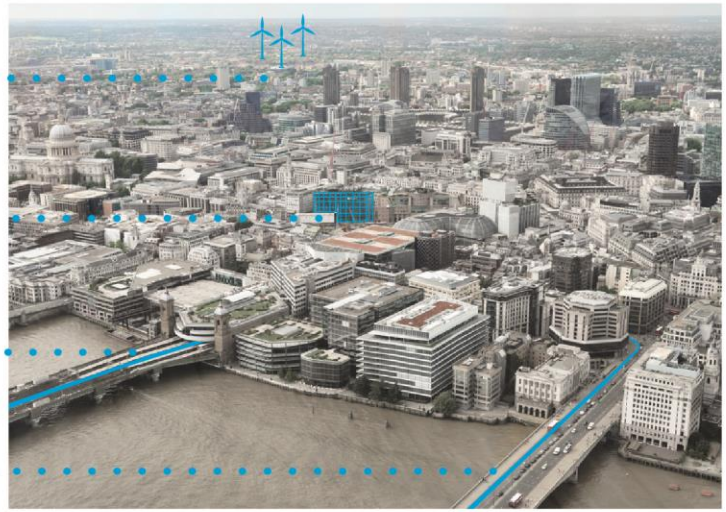
CITY PERFORMANCE TOOL

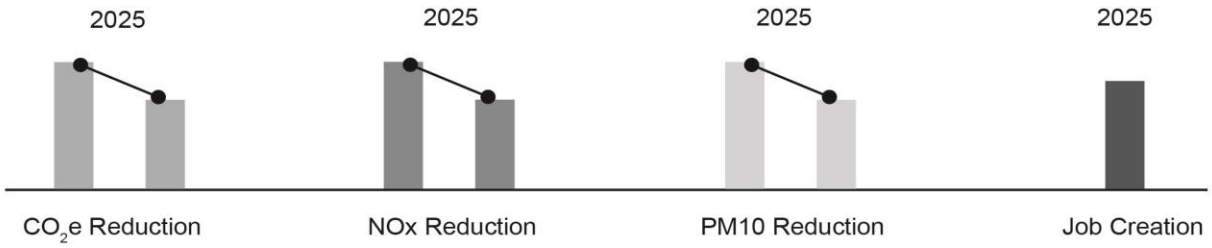
WIND POWER

BUILDING INSULATION

AUTOMATED TRAIN OPERATION SYSTEM (ATO)

BUS RAPID TRANSIT





How the CyPT Works

1 Collect Data

Siemens collaborates with the City to collect data, which are used to customize the model.

2 Environmental Baseline

The model calculates the city's environmental baseline.

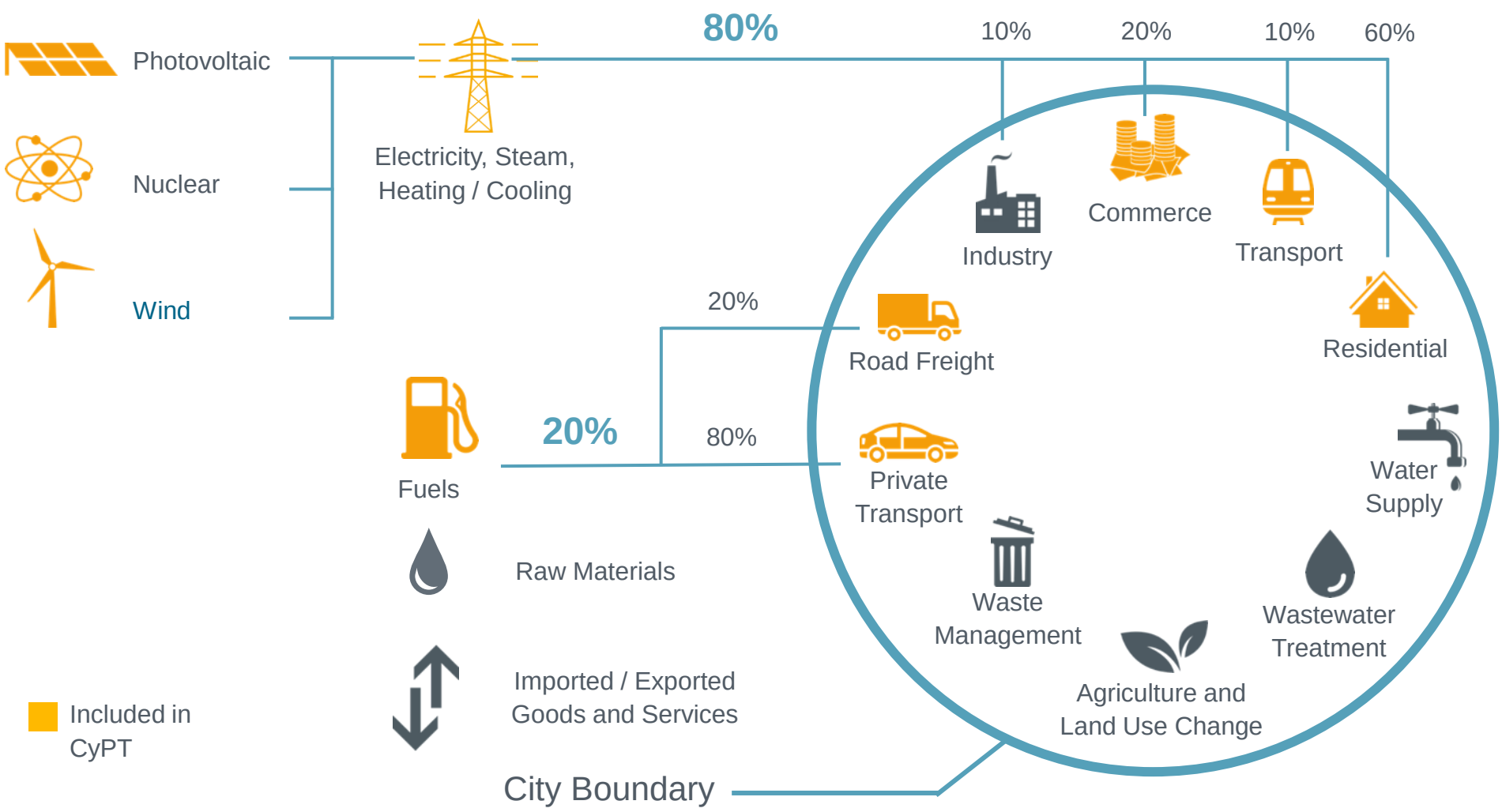
3 Infrastructure Technology Impacts

The model calculates the infrastructure technology impacts.

4 Infrastructure Strategy

Siemens works with the City to develop an infrastructure strategy based on future scenarios.

Scope of the CyPT



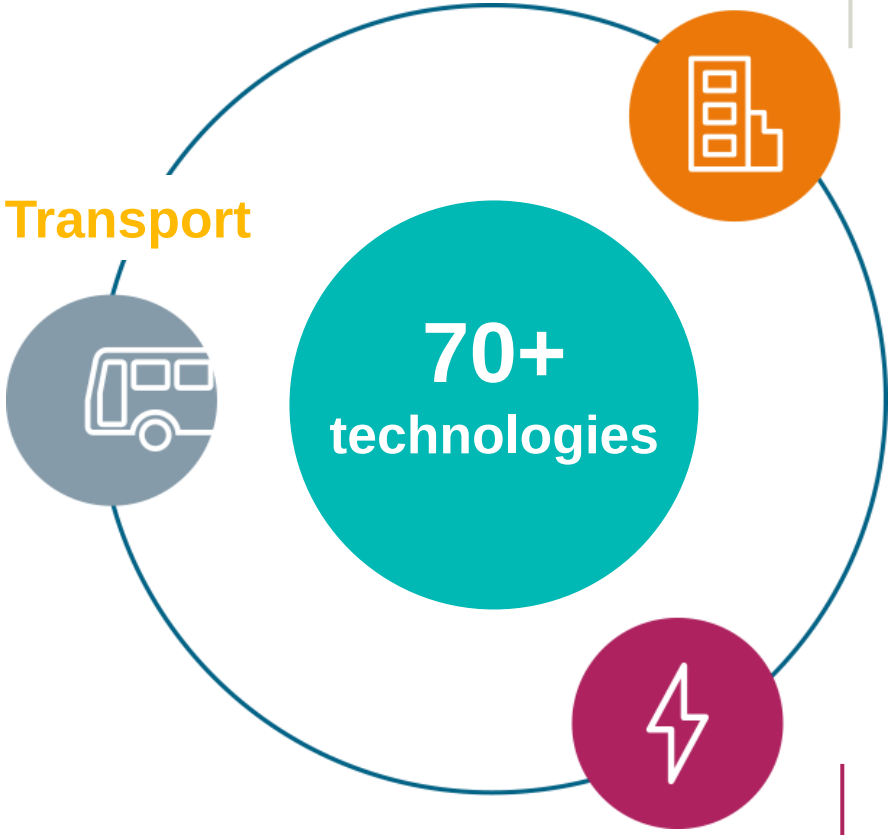
CyPT Technologies

Buildings

- Building envelope
- Building automation
- Monitoring and optimization

Transport

- Public transport
- Private transport
- Traffic management
- Freight



Energy

- Renewable generation
- Grid management

The Minneapolis Context

Why Minneapolis Decided to Use the CyPT

- Minneapolis has adopted aggressive goals to reduce GHG emissions 15% by 2015, 30% by 2025 and 80% or more by 2050.
- The City's Climate Action Plan (adopted in 2013) identifies a roadmap for meeting the 2025 goal.
- The City and its two energy utilities recently formed the Minneapolis Clean Energy Partnership to pursue these climate goals together.
- The City is interested in using the CyPT model to analyze the technical potential for meeting the 2050 emissions reduction goal.
- CyPT analysis could form the basis for updating the City's Climate Action Plan in future years to include the 2050 goal.

Minneapolis Today

Population:

404,000

inhabitants

Electricity Consumption per Capita:

4,128

kWh

Avg. Household Size:

1,800

ft^2

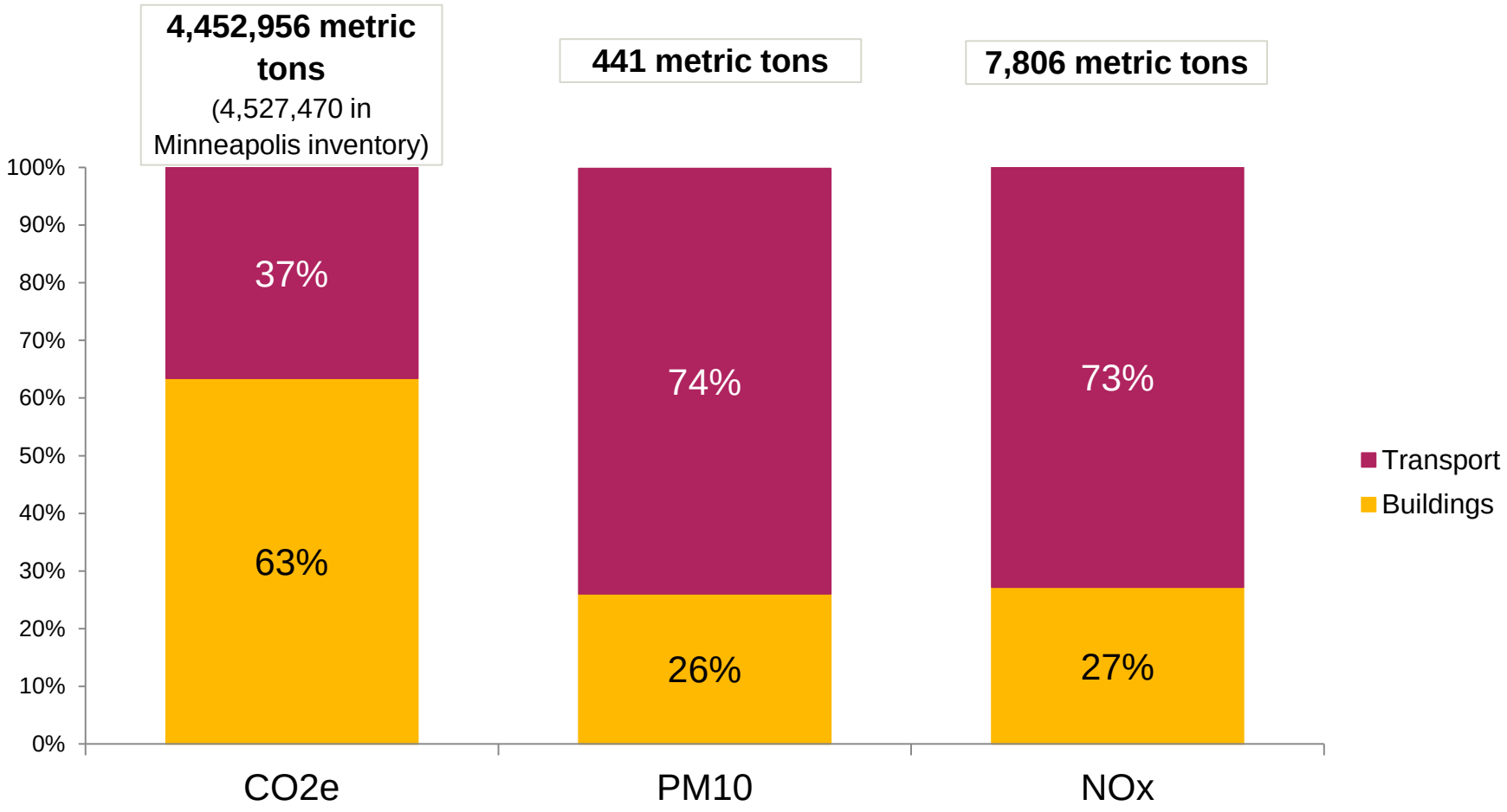
Public Transit Mode Share:

6%

of passenger miles

Sources of Emissions in CyPT Scope, by Sector

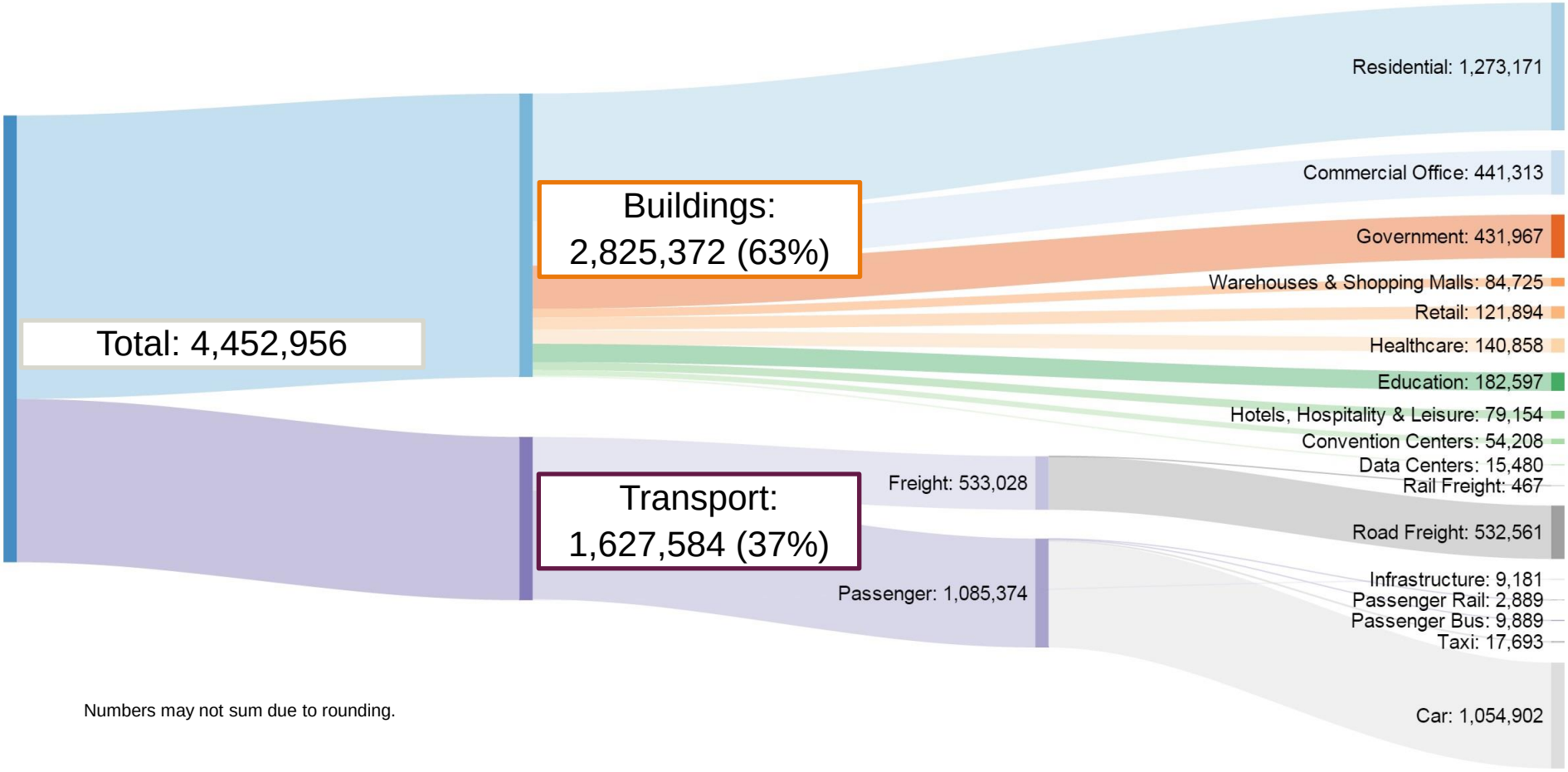
Annual CO_2e, PM10 and NOx emissions Today



Breakdown of CO_2e Emissions in CyPT Scope

Annual CO_2e emissions Today, by Sector

(metric tons)



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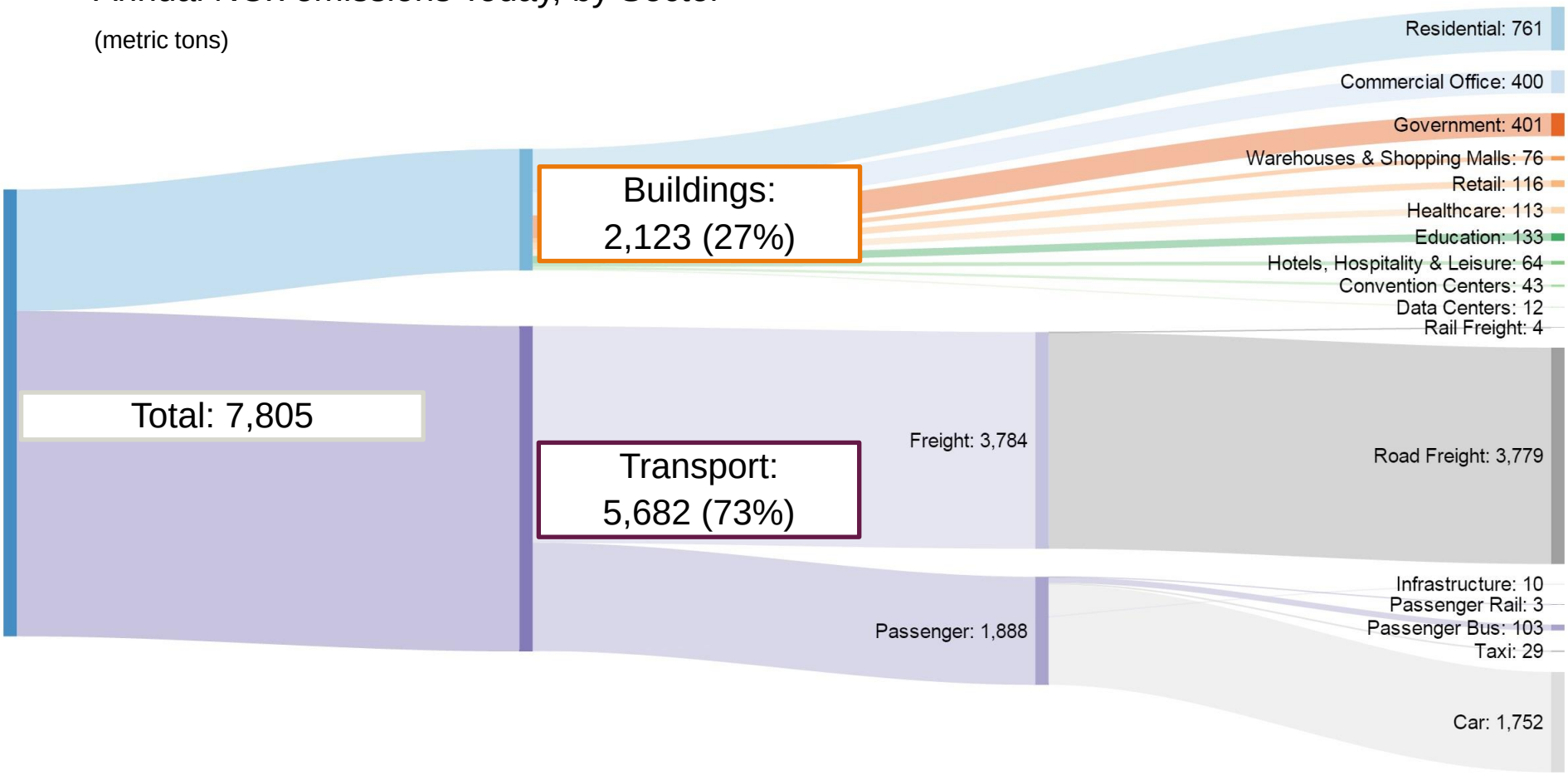
Breakdown of Criteria Pollutants in CyPT Scope (NOx)

Annual NOx emissions Today, by Sector

(metric tons)



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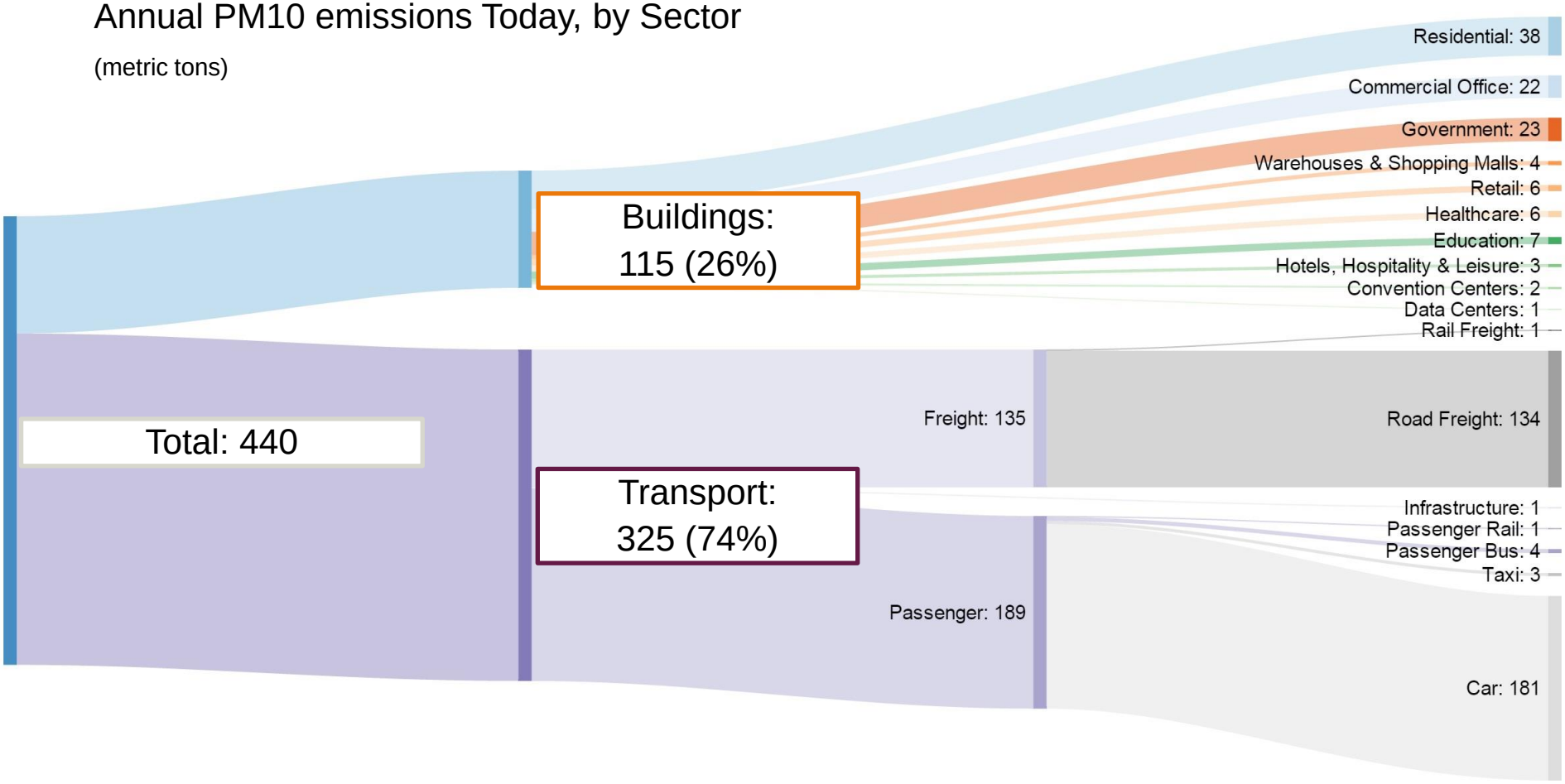
Breakdown of Criteria Pollutants in CyPT Scope (PM10)

Annual PM10 emissions Today, by Sector

(metric tons)



Numbers may not sum due to rounding.

CyPT Scenarios

3 Energy Scenarios

1) Control, 2) Xcel Energy Revised Proposal, and 3) Climate Champion

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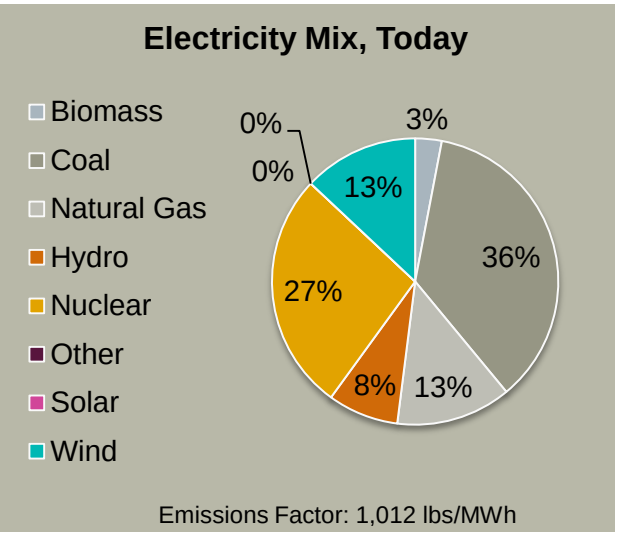
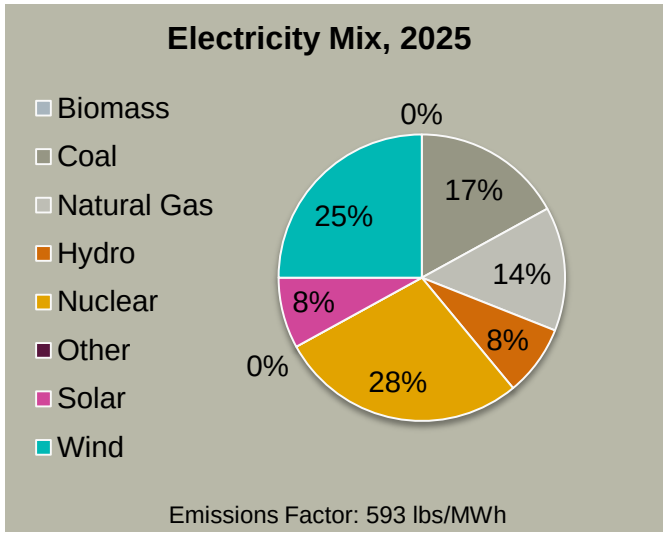
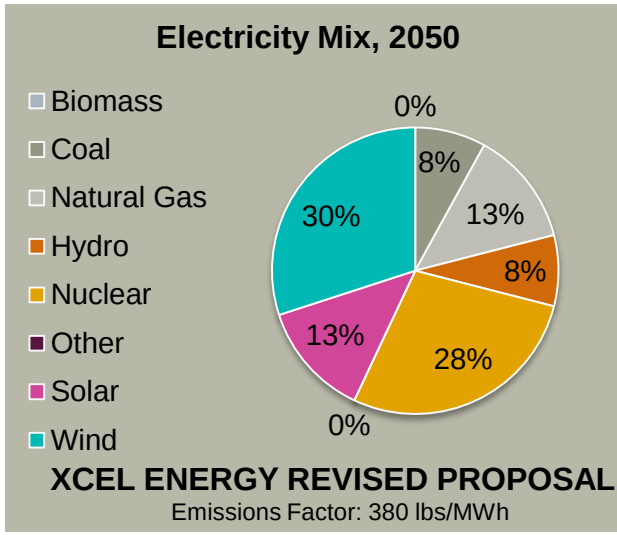
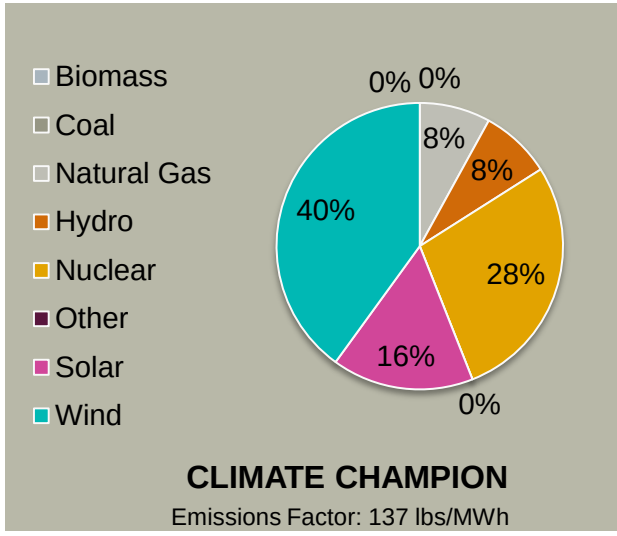
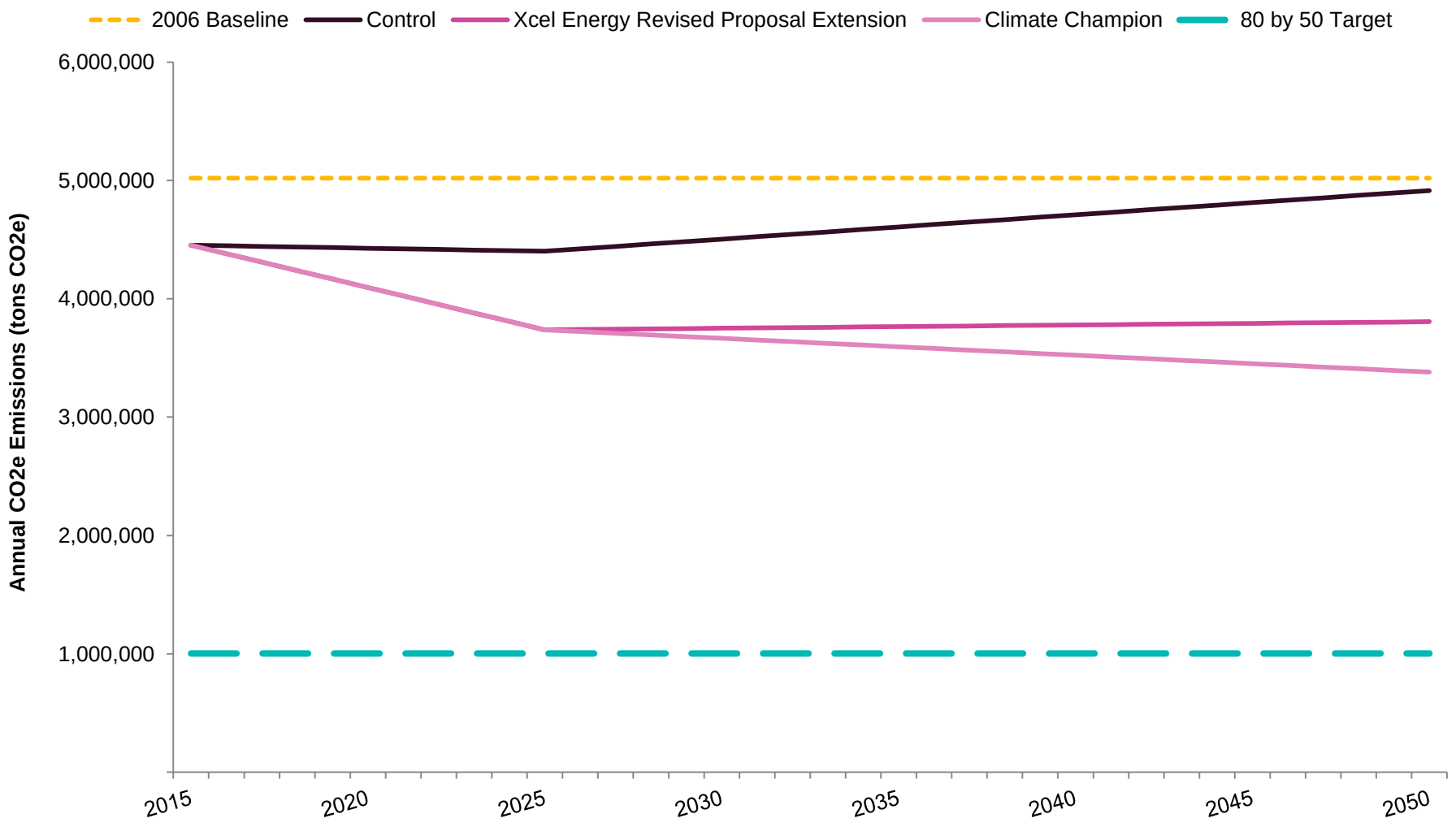




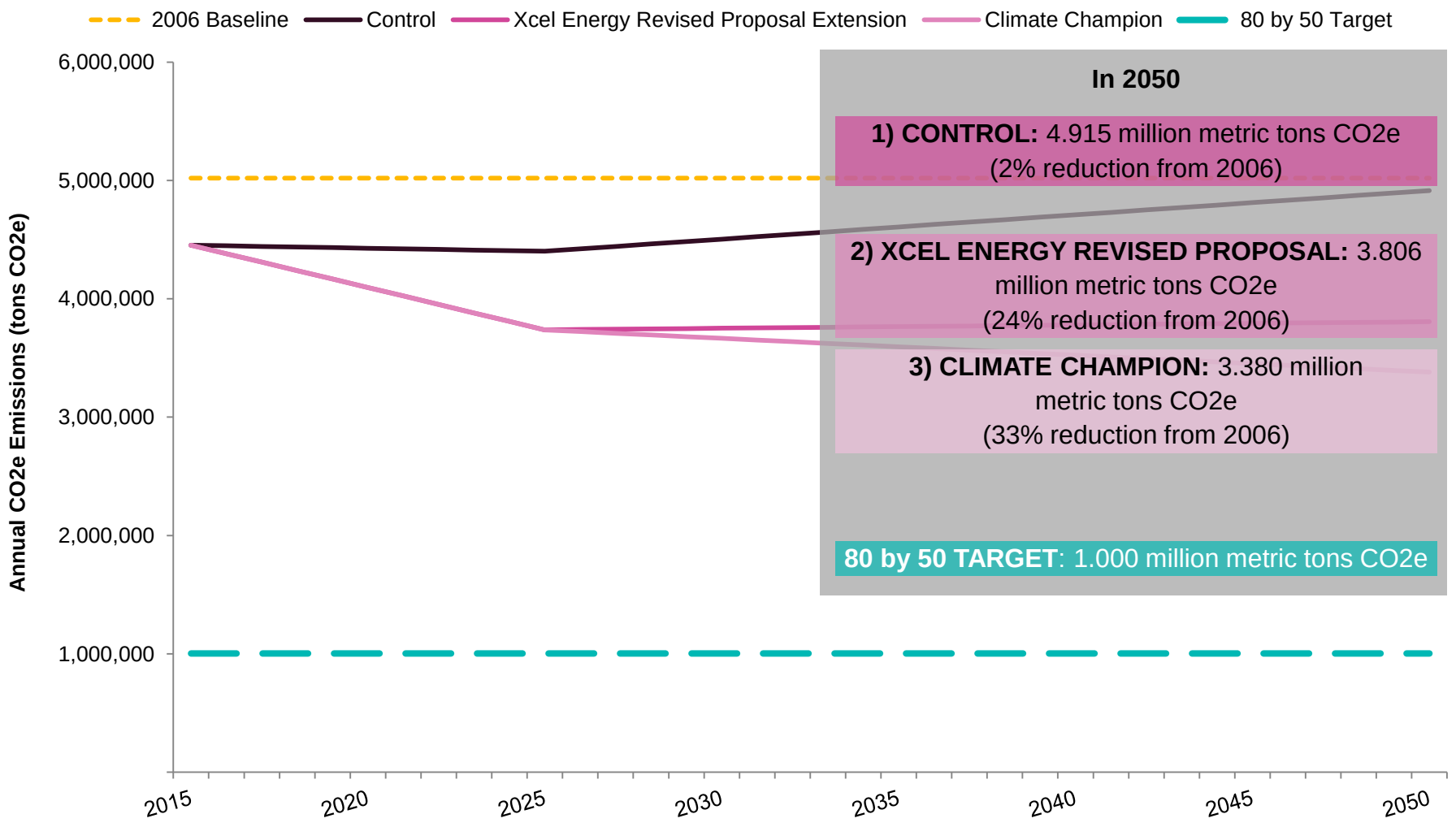




3 Energy Scenarios
Emissions, without Application of CyPT Technologies

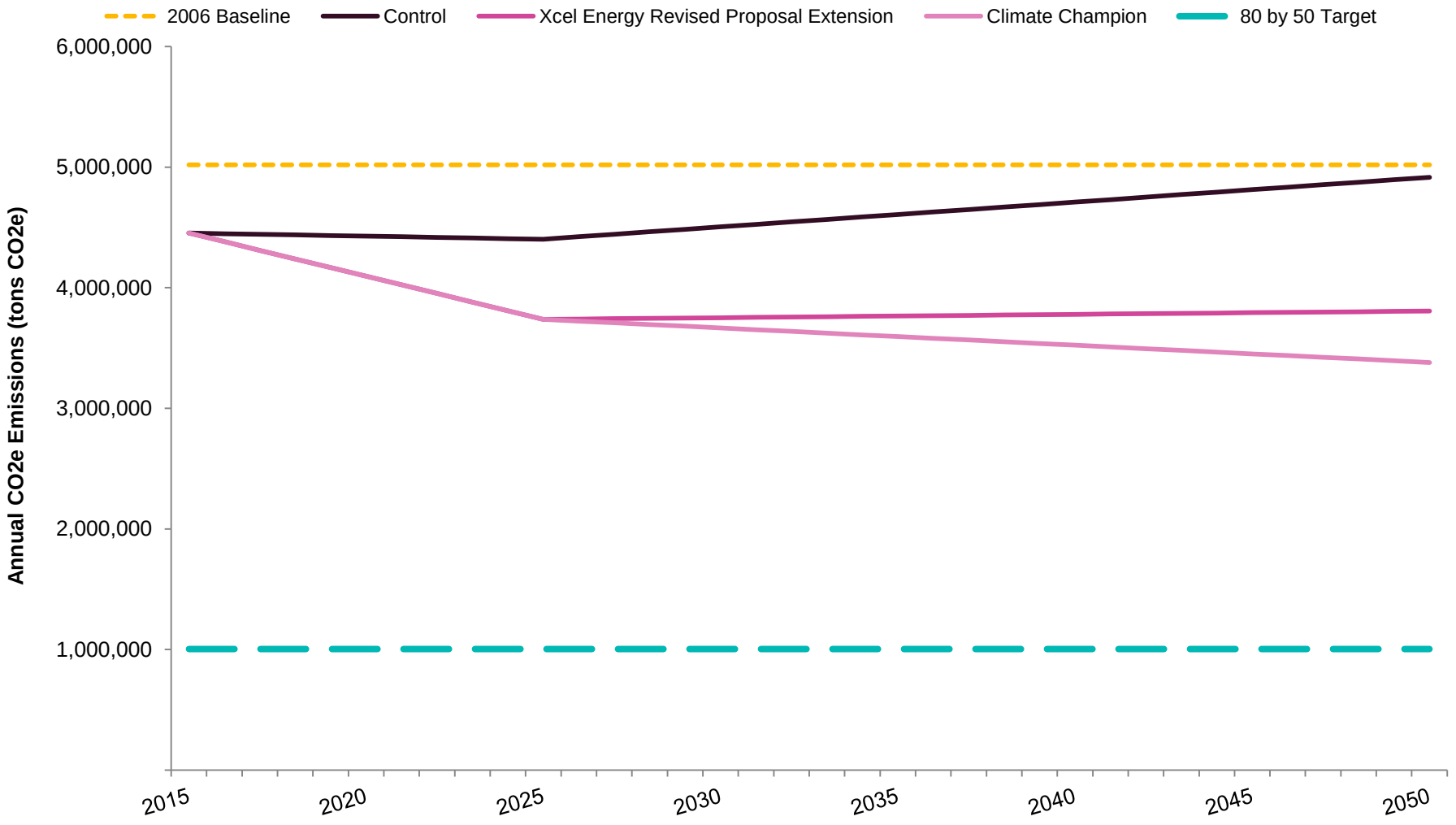


3 Energy Scenarios
Emissions, without Application of CyPT Technologies

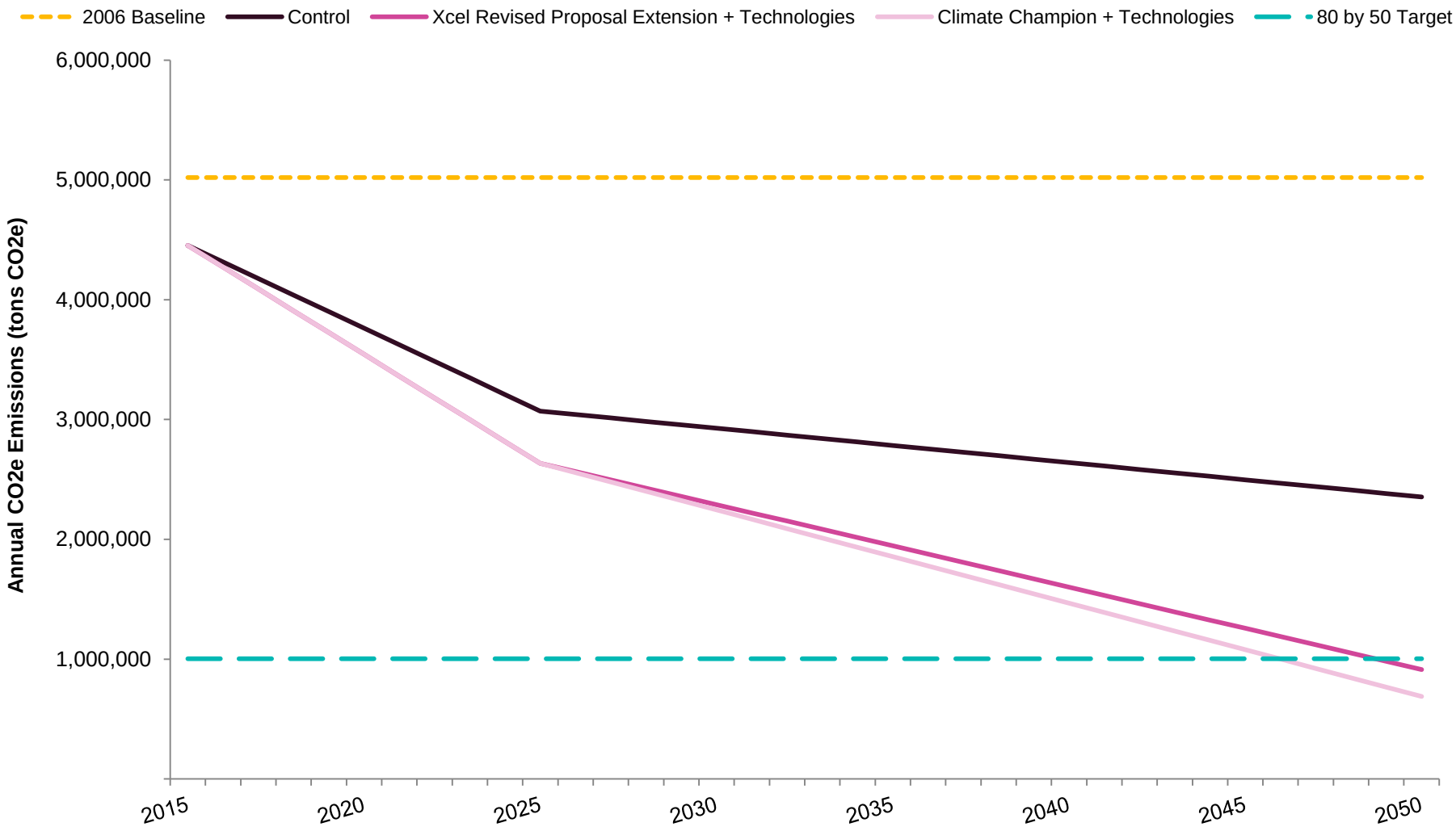


80 by 50?

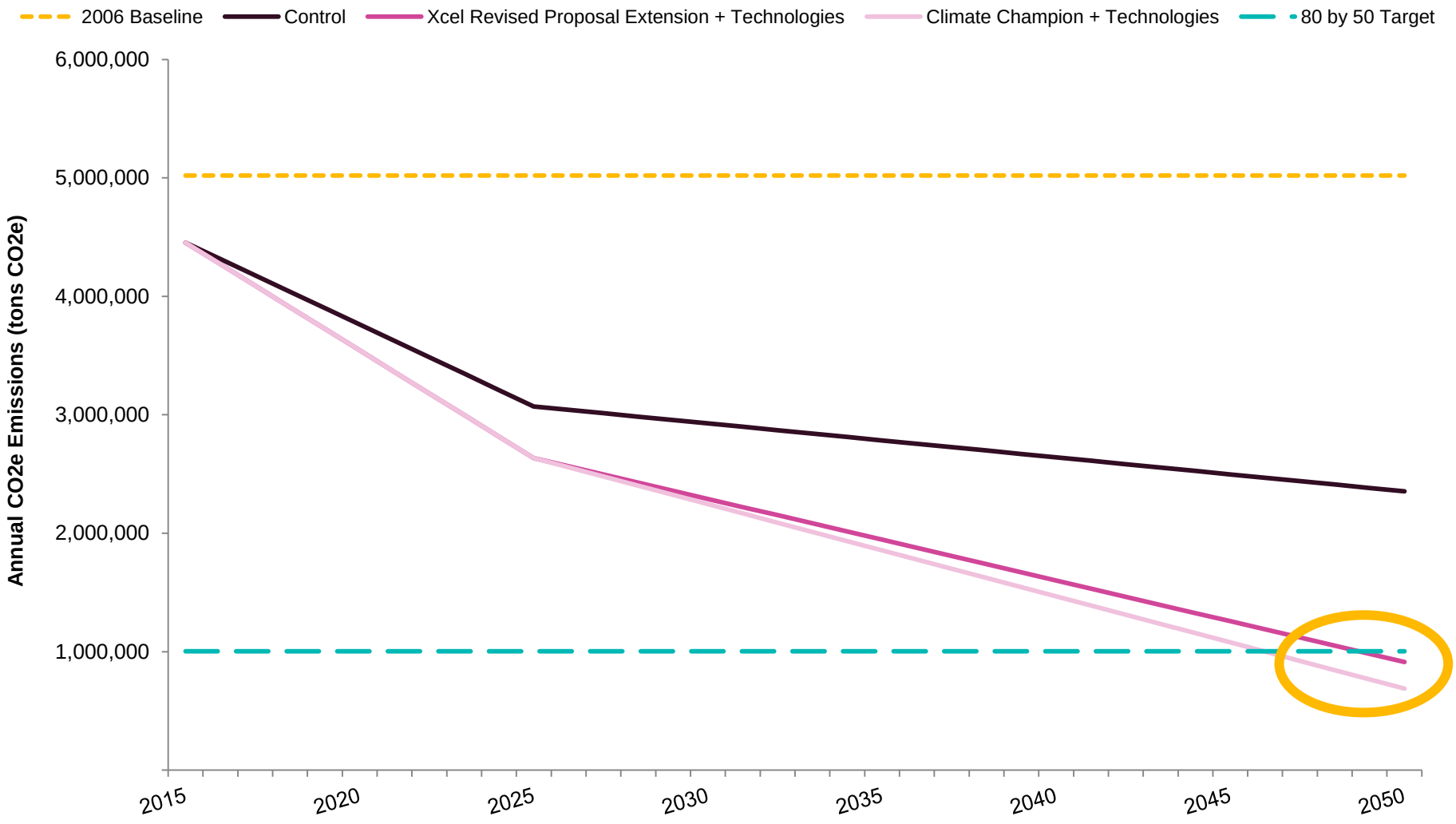
3 Energy Scenarios
Emissions, without Application of CyPT Technologies



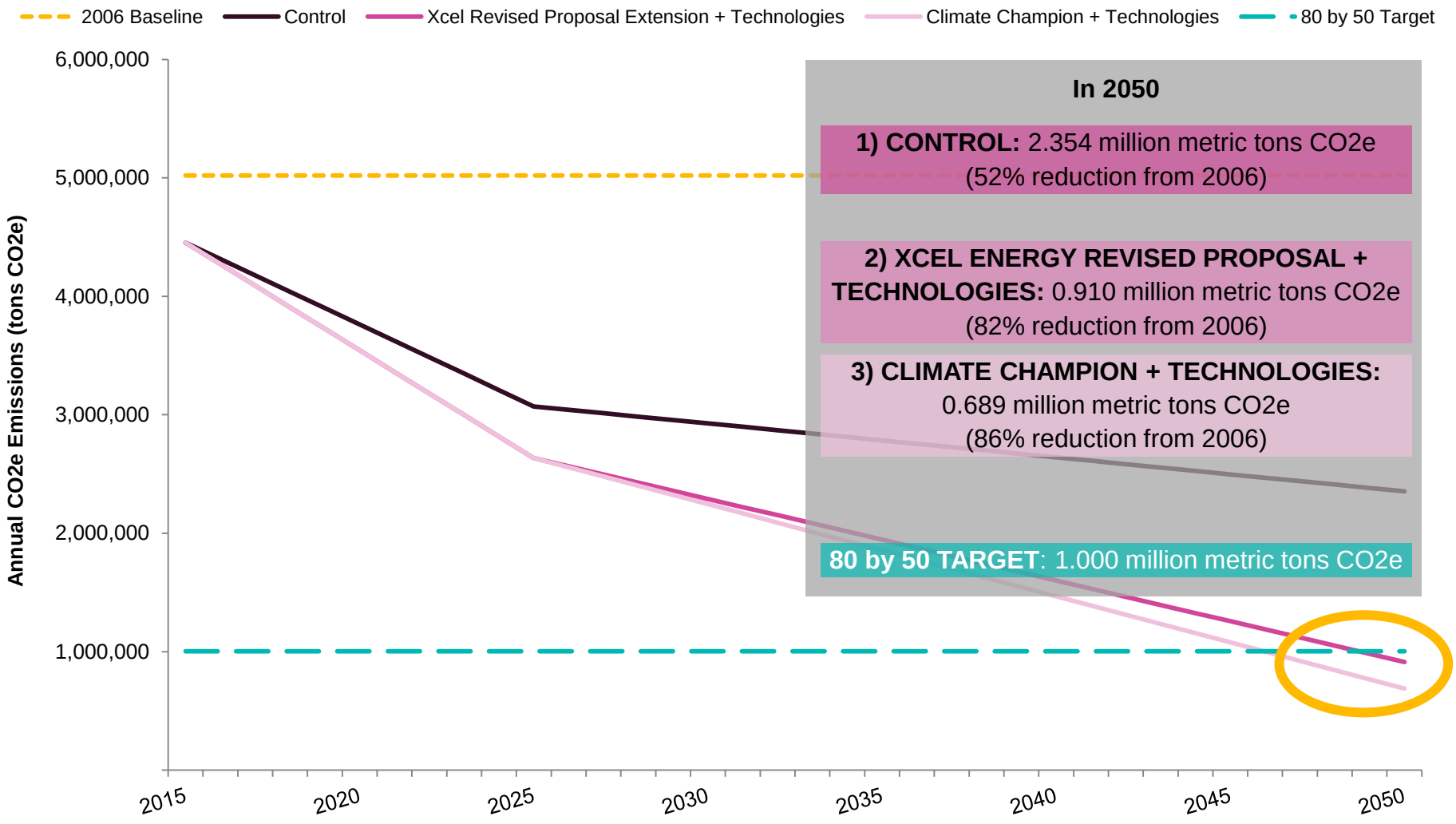
80 by 50?
Emissions, with Application of 40 CyPT Technologies



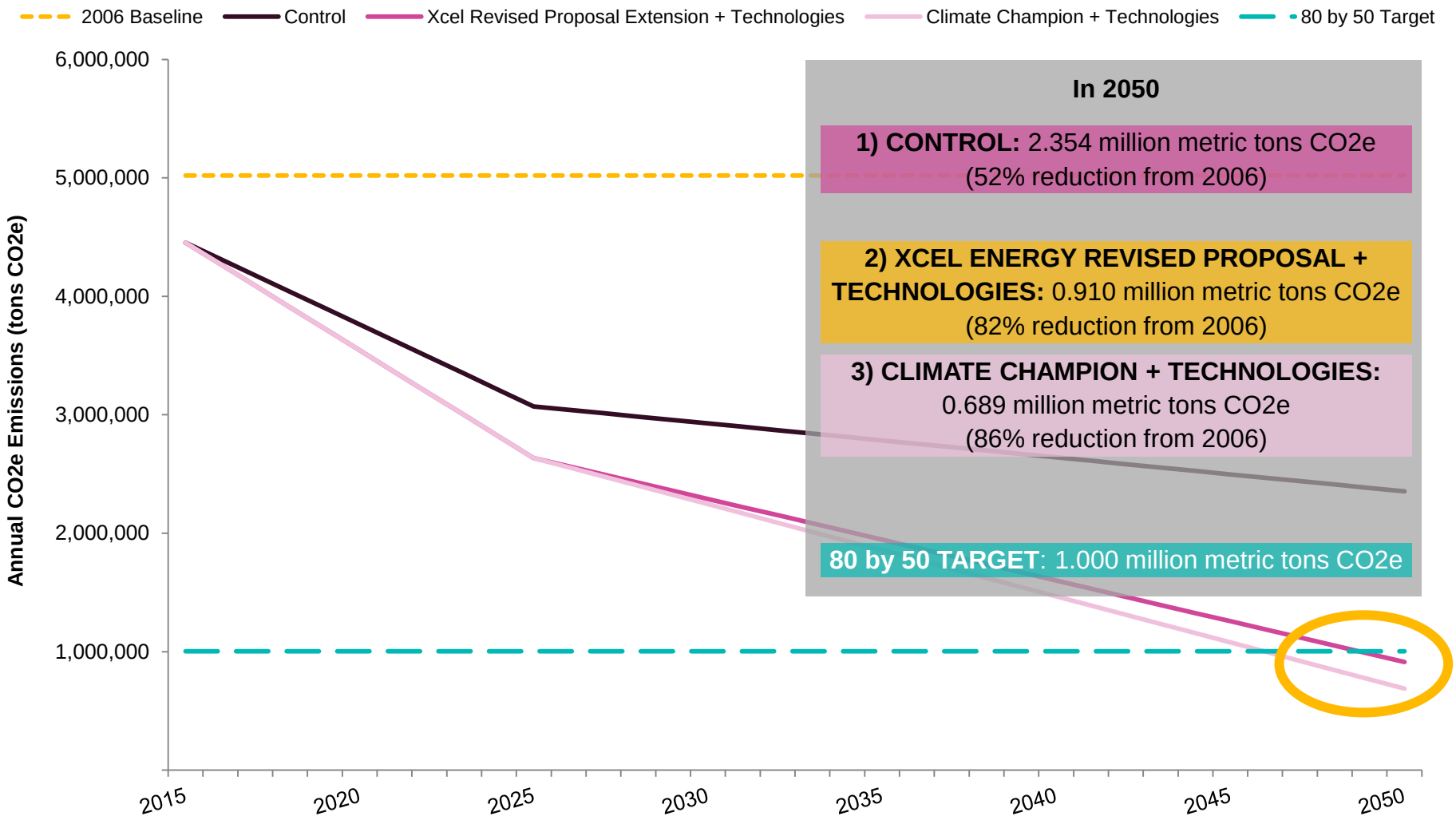
80 by 50!
Emissions, with Application of 40 CyPT Technologies



80 by 50!
Emissions, with Application of 40 CyPT Technologies



80 by 50!
Emissions, with Application of 40 CyPT Technologies



Xcel Revised Energy Proposal Extension

Implementation Rates for 40 CyPT Technologies

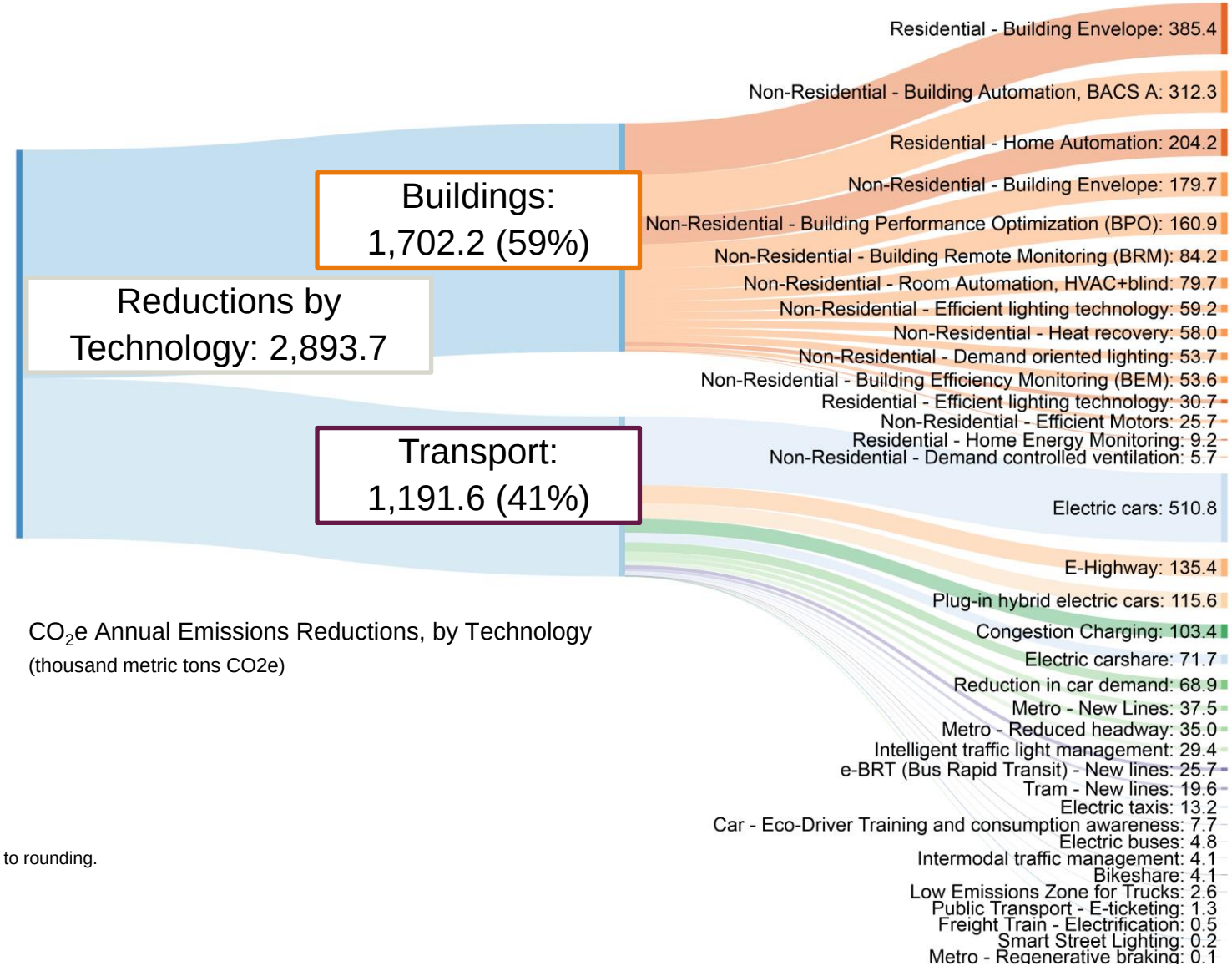
Sector	Lever	IR	Unit
BUILDINGS			
Residential	Efficient lighting technology (LEDs)	8%	share of existing residential building stock fitted each year
	Home Energy Monitoring	3%	share of existing residential building stock fitted each year
	Home Automation	3%	share of existing residential building stock fitted each year
	Building Envelope	3%	share of existing residential building stock fitted each year
Non-Residential	Efficient lighting technology (LEDs)	10%	share of existing non-residential building stock fitted each year
	Demand oriented lighting	8%	share of existing non-residential building stock fitted each year
	Building Efficiency Monitoring (BEM)	5%	share of existing non-residential building stock fitted each year
	Building Performance Optimization (BPO)	5%	share of existing non-residential building stock fitted each year
	Demand controlled ventilation	6%	share of existing non-residential building stock fitted each year
	Heat recovery	6%	share of existing non-residential building stock fitted each year
	Building Envelope	5%	share of existing non-residential building stock fitted each year
	Building Automation, BACS A	3%	share of existing non-residential building stock fitted each year
	Efficient Motors	6%	share of existing non-residential building stock fitted each year
	Room Automation, HVAC+blind	3%	share of existing non-residential building stock fitted each year
	Building Remote Monitoring (BRM)	8%	share of existing non-residential building stock fitted each year
TRANSPORT			
Vehicles	Reduction in car demand	10%	reduction in car pmi, reallocated to other modes
	Electric cars	65%	share of car fleet replaced
	Plug-in hybrid electric cars	25%	share of car fleet replaced
	Electric taxis	100%	share of taxi fleet replaced
	Electric car sharing	7	cars pr 1000 inhabitants
	Car - Eco-Driver Training and consumption awareness	8%	share of driving license holders trained
Public Transit	Automated train operation (ATO) - Metro	1	share of lines equipped
	Metro - New lines	5	number of new lines
	Metro - New vehicles	1	share of fleet replaced
	Metro - Reduced headway	180	peak-time headway [s]
	Electric buses	1	share of fleet replaced
	Automated train operation (ATO) - Regional Train	1	share of lines equipped
	Tram - New line	4	number of new lines
	e-BRT - New line	10	number of new lines
	Bikeshare	20	bikes pr 1000 ihabitants
	Protected bike lane	25.8	miles of new protected bike lanes pr 100k inhabitants
	Public Transport - E-ticketing	1	users as share of travelers
Infrastructure	LED Street lighting	1	share of street lights replaced
	Smart Street Lighting	1	share of street lights replaced
	Car & Motorcycle - City tolling	15%	reduction in road traffic
	Intelligent traffic light management	1	share of coordinated traffic lights
	Intermodal traffic management	1	users as share of travelers
Freight	E-Highways	50%	share of highway equipped
	Freight Train - Electrification	1	share of electrified railway equipped
	Trucks - Low emission zone	6	minimum EURO class standard to enter low emission zone

80 by 50!

Xcel Revised Proposal Extension + Technologies

82%

Reduction in Annual **CO_2e** Emissions between 2006 and 2050



CO_2e Annual Emissions Reductions, by Technology
(thousand metric tons CO2e)

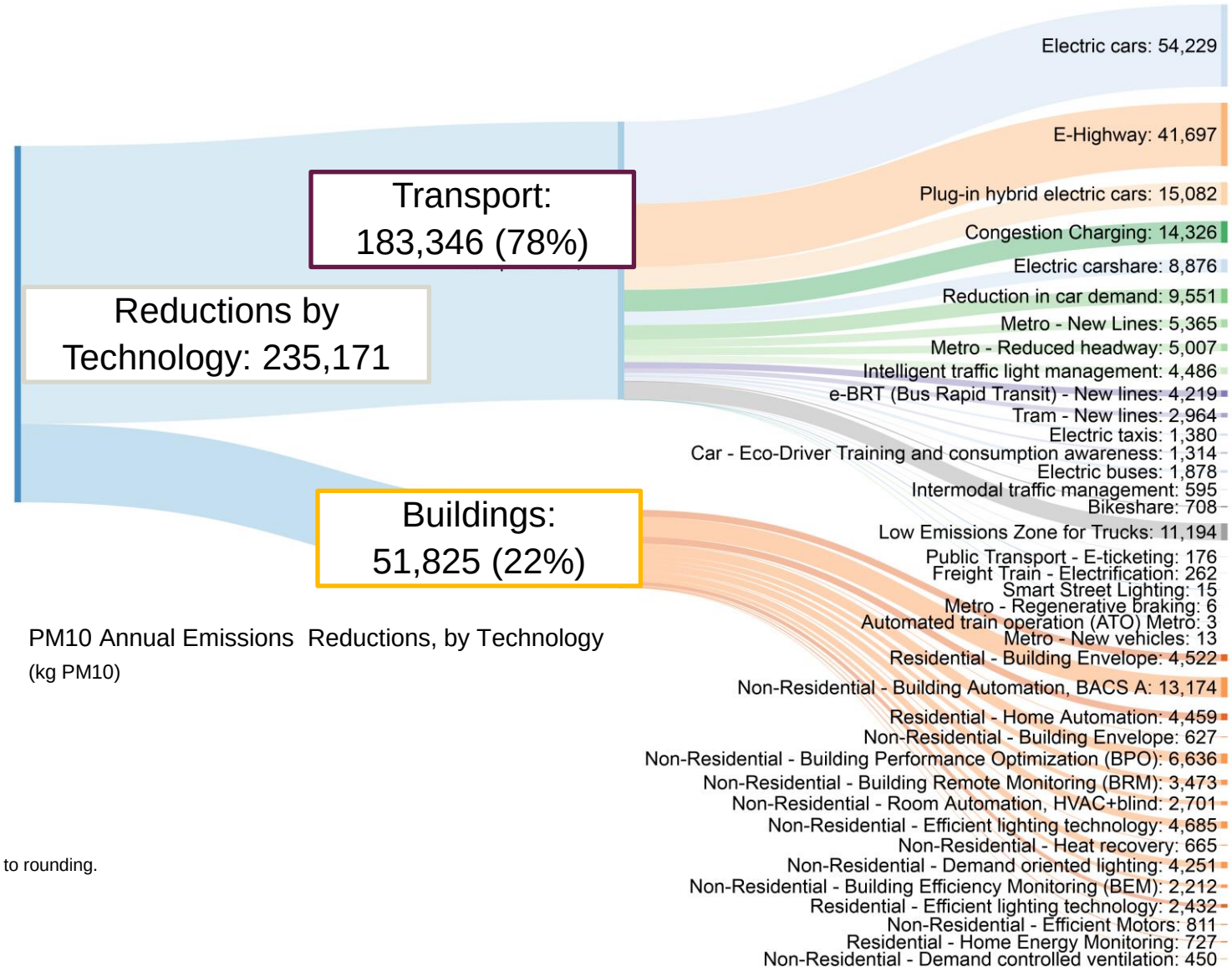
Numbers may not sum due to rounding.

80 by 50!

Xcel Revised Proposal Extension + Technologies

61%

Reduction in **PM10** Annual Emissions between 2006 and 2050



PM10 Annual Emissions Reductions, by Technology
(kg PM10)

Numbers may not sum due to rounding.

80 by 50!

Xcel Revised Proposal Extension + Technologies

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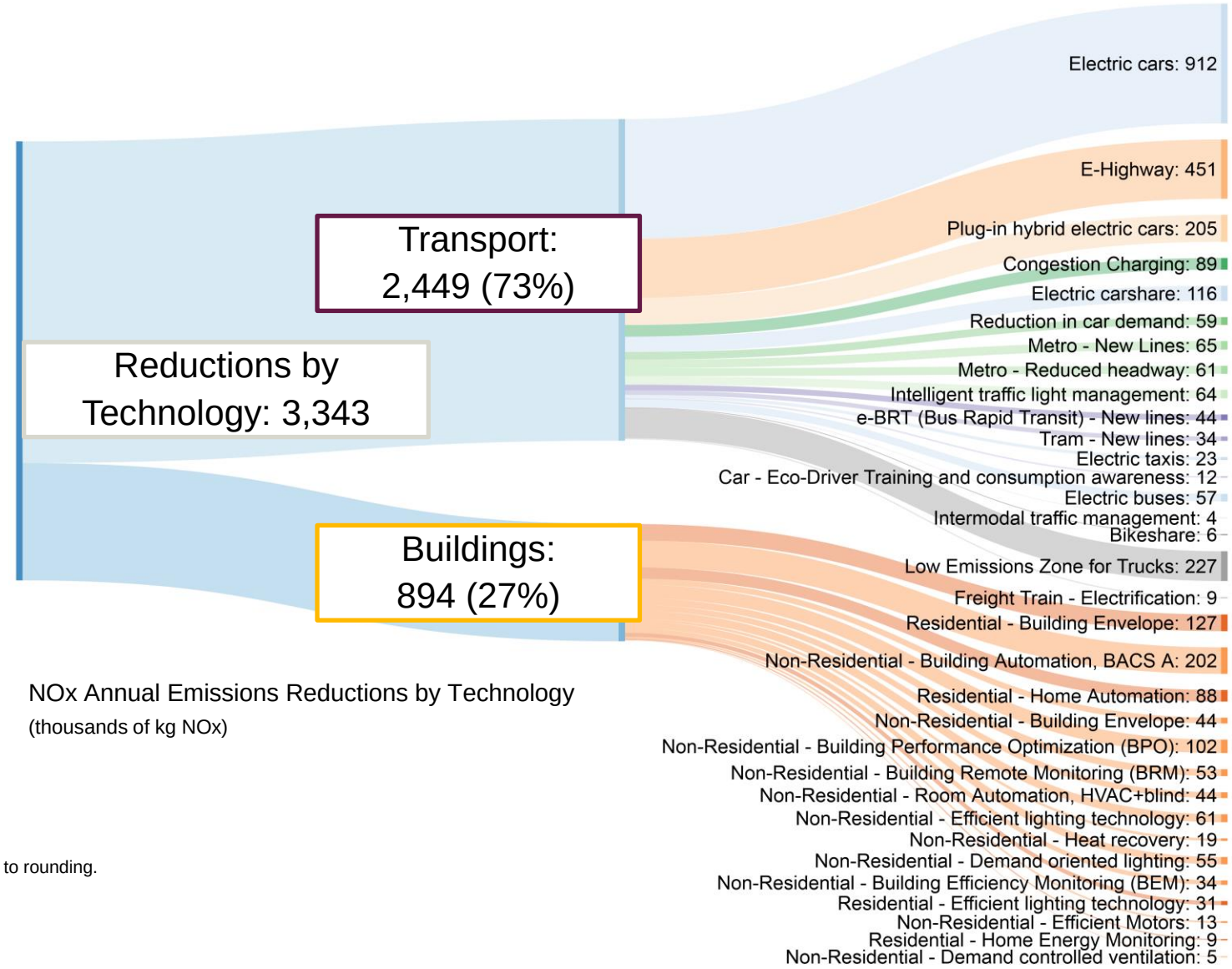
73%

Reduction in **NOx** Annual Emissions between 2006 and 2050



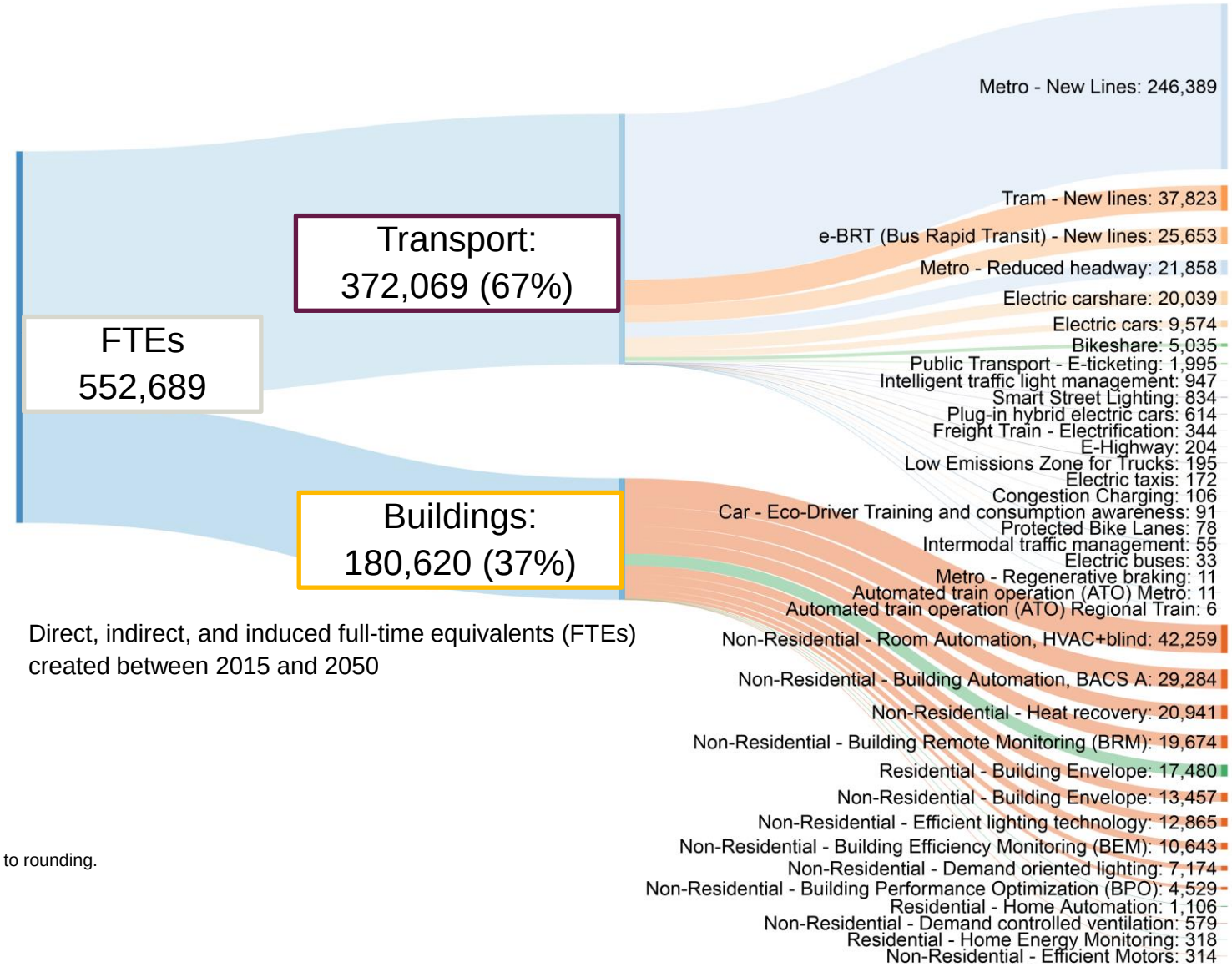
NOx Annual Emissions Reductions by Technology
(thousands of kg NOx)

Numbers may not sum due to rounding.

80 by 50!
Xcel Revised Proposal Extension + Technologies

>550k

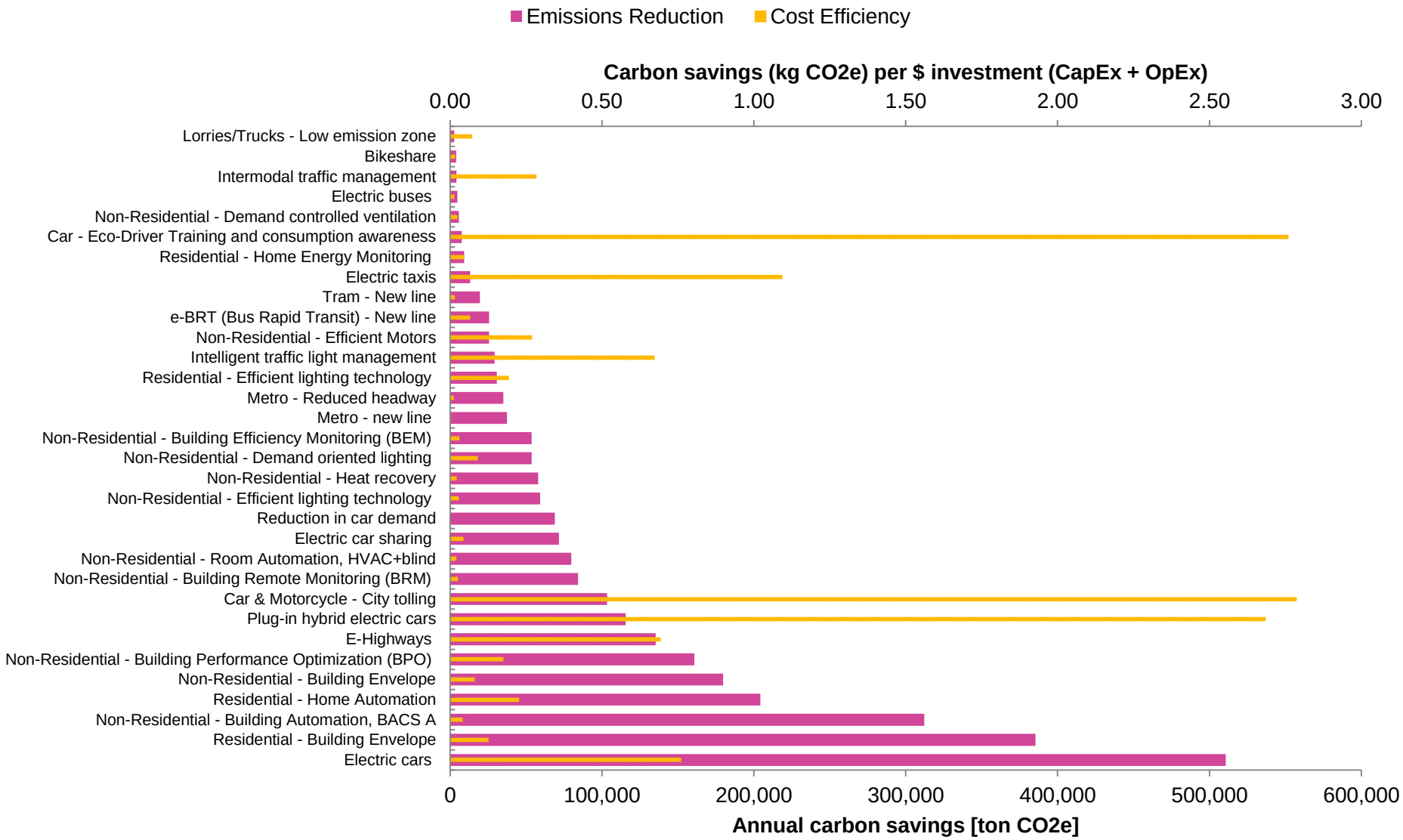
Direct, indirect, and induced **FTEs** created between 2015 and 2050



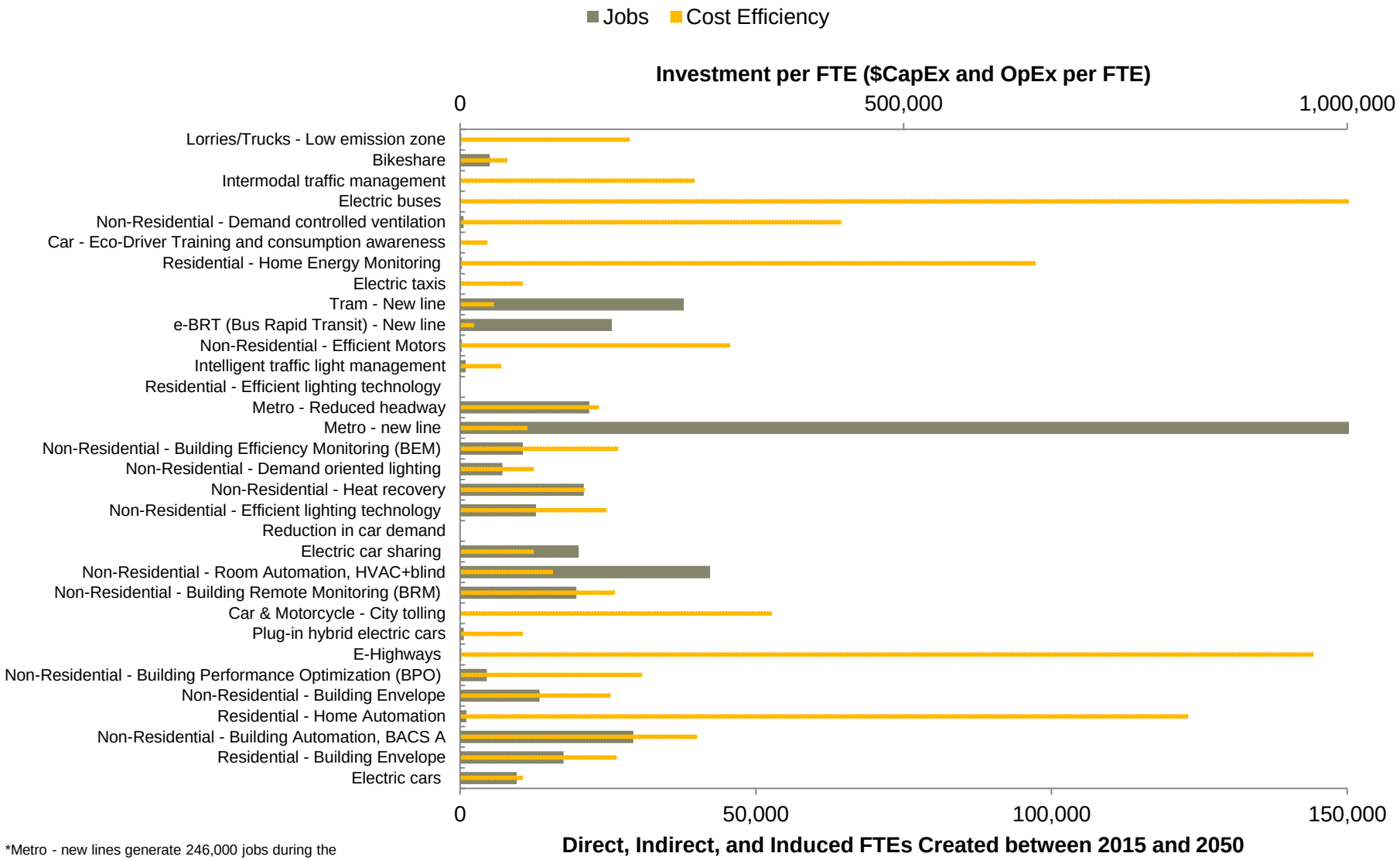
Direct, indirect, and induced full-time equivalents (FTEs) created between 2015 and 2050

Numbers may not sum due to rounding.

Top Strategies for Reducing Carbon Emissions



Top Strategies for Creating Jobs (FTEs)



*Metro - new lines generate 246,000 jobs during the period of investment.

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High-Impact Technologies

The Path to 80 by 50

As the energy mix gets cleaner, Minneapolis could pursue a stepwise approach to reaching 80 by 50, with the City taking the lead to green its own buildings and fleet and install electric charging infrastructure, while encouraging inhabitants to purchase electric vehicles, ride public transport, and pursue energy efficiency projects in their own homes and businesses.

High-Impact Technologies

1) Energy Efficiency and Automation in Buildings

The City of Minneapolis could take the lead in retrofitting and automating its buildings.

3) Reduction in Car Demand

As inhabitants use their cars less, use of other passenger transport modes (walking, cycling, transit) increase.

2) Combined Heat and Power

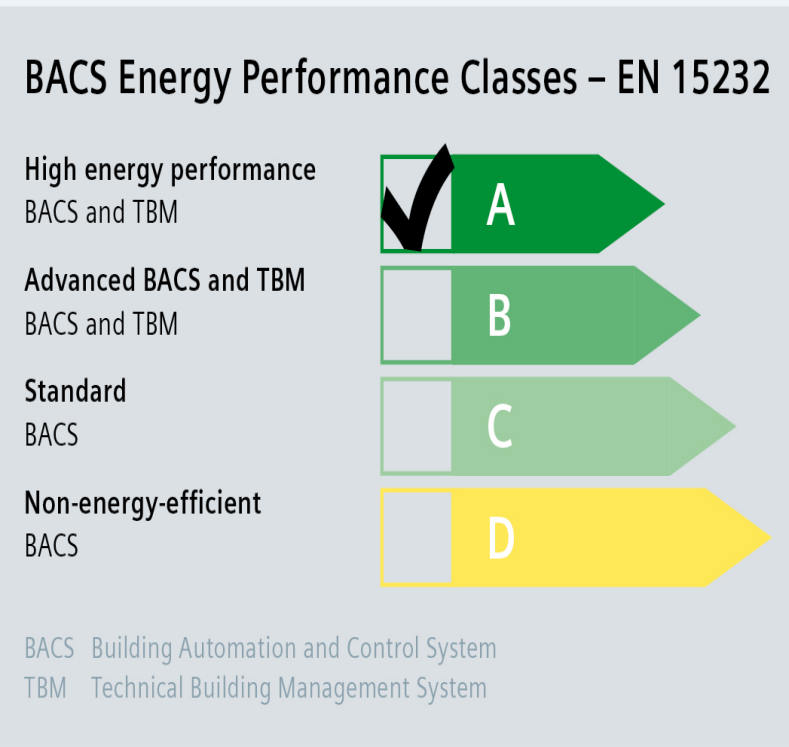
Using Combined Heat and Power (CHP) could provide short-term emissions reduction, as Xcel greens its energy supply.

4) Electric Cars

Infrastructure for electric charging could be built for use by cars, buses, and freight.

1) Energy Efficiency and Automation in Buildings

Non-Residential – Building Automation, BACS A



BACS A buildings have:

- Networked room automation with automatic demand control
- Scheduled maintenance
- Energy monitoring
- Sustainable energy optimization

<45% of non-residential buildings have wall insulation

3% of existing building stock retrofitted every year

Reductions in annual emissions from today to 2050:

CO2e – 312,000 mt (8.2%)

NOx – 30,000 kg (4.4%)

PM10 – 13,000 kg (3.3%)

Jobs Created

29,000 FTEs

(60% semi-skilled)

$266,000 Cost per FTE

(CapEx and OpEx estimates are for both public and private sectors)

1) Energy Efficiency and Automation in Buildings
Non-Residential – Building Performance Optimization

- Service to optimize the energy efficiency of a building by adapting building control strategies, operation guidelines, and/or adjusting HVAC system settings

5% of existing building stock retrofitted every year

Reductions in annual emissions from today to 2050:
CO2e – 161,000 mt (4.2%)
NOx – 103,000 kg (2.2%)
PM10 – 6,700 kg (1.7%)

Jobs Created
4,500 jobs

$205,000 Cost per Job
(CapEx and OpEx estimates are for both public and private sectors)

1) Energy Efficiency and Automation in Buildings
Residential – Building Envelope

- Includes insulation, high-performing glazing and air-tight construction for floors, roofs, walls, and facades.

3% of existing building stock retrofitted every year

Reductions in annual emissions from today to 2050:
CO2e – 385,000 mt (10.1%)
NOx – 127,000 kg (2.8%)
PM10 – 4,500 kg (1.1%)

Investment of ~$20k per household

Jobs Created
17,000 jobs

$176,000 Cost per Job
(CapEx and OpEx estimates are for both public and private sectors)

2) Combined Heat and Power (CHP)

- Generates electricity and heating from a single fuel source at the point of use
- Base emissions are allocated ~20% to heat generation, ~80% to electricity generation
- Savings depend on “cleanness” of electricity mix

30% of total heating generated by CHP in 2050

Reductions in annual emissions from today to 2050:

CO2e – 503,000 mt (13.2%)

NOx – -741,000 kg (-16.2%)

PM10 – 36,000 kg (9.0%)

Jobs Created

11,492 jobs

$69,000 Cost per Job

3) Reduction in Car Demand

10% shift of car demand distributed equally to all other transport modes

Reductions in annual emissions from today to 2050:

CO2e – 69,000 mt (1.8%)

NOx – 60,000 kg (1.3%)

PM10 – 9,600 kg (2.4%)

- Reduction in passenger miles by car distributed to all other modes based on their relative modal share.
- Could include a variety of measures, including improved public transport or tax incentives to reduce car use.

Jobs Created

Zero

Requires shift in car modal share from >90% to 57%

4) Electric Cars

- Assumes that e-cars replace a certain share of total cars (including private cars) in the city and that the City installs and operates e-car charging infrastructure

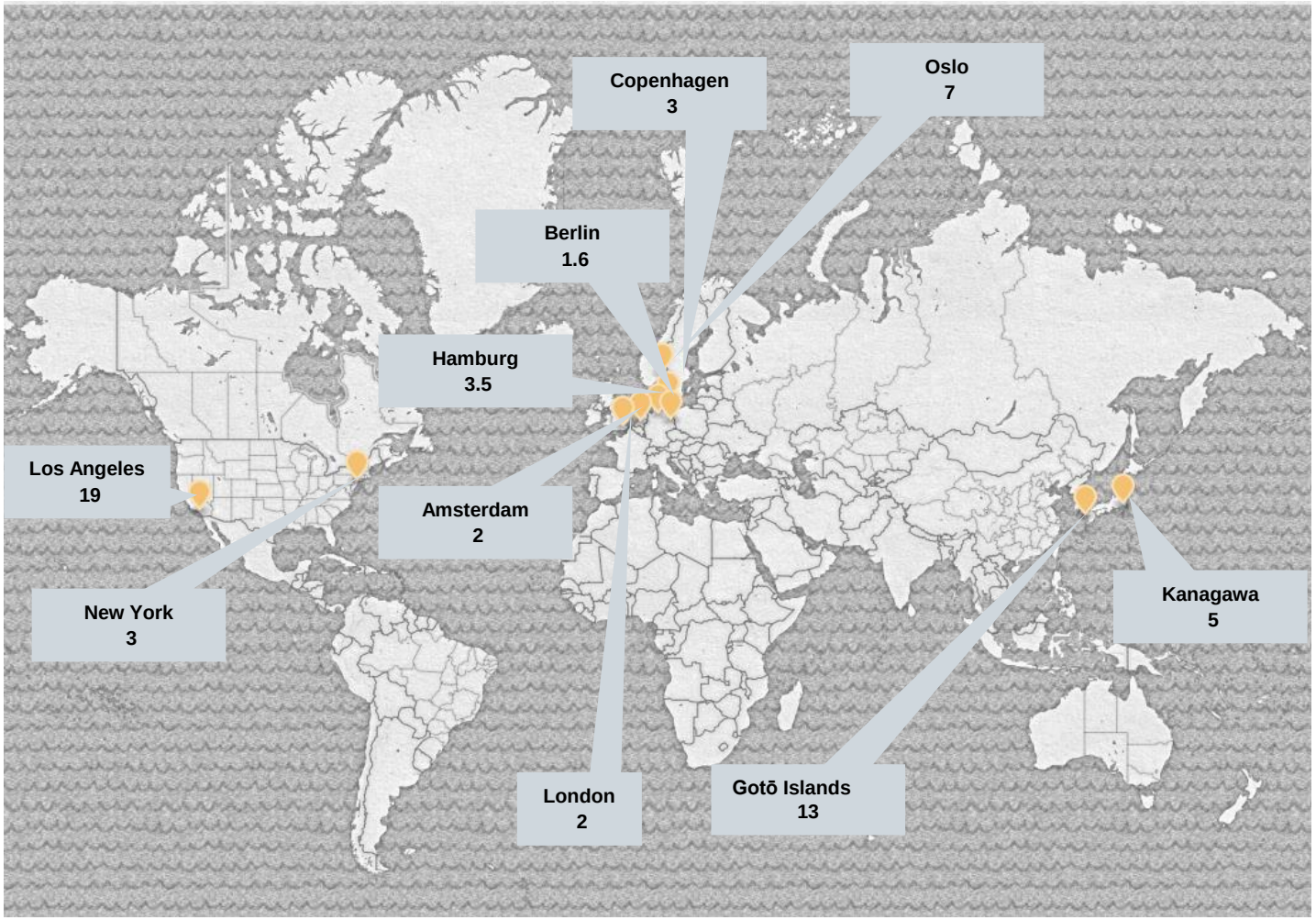
65% of conventional combustion cars replaced with electric

Reductions in annual emissions from today to 2050:
CO2e – 510,000 mt (13.4%)
NOx – 921,000 kg (19.9%)
PM10 – 54,000 kg (13.7%)

Jobs Created
9,574 semi-skilled

$70,000 Cost per Job
(CapEx and OpEx estimates are for public charging infrastructure only)

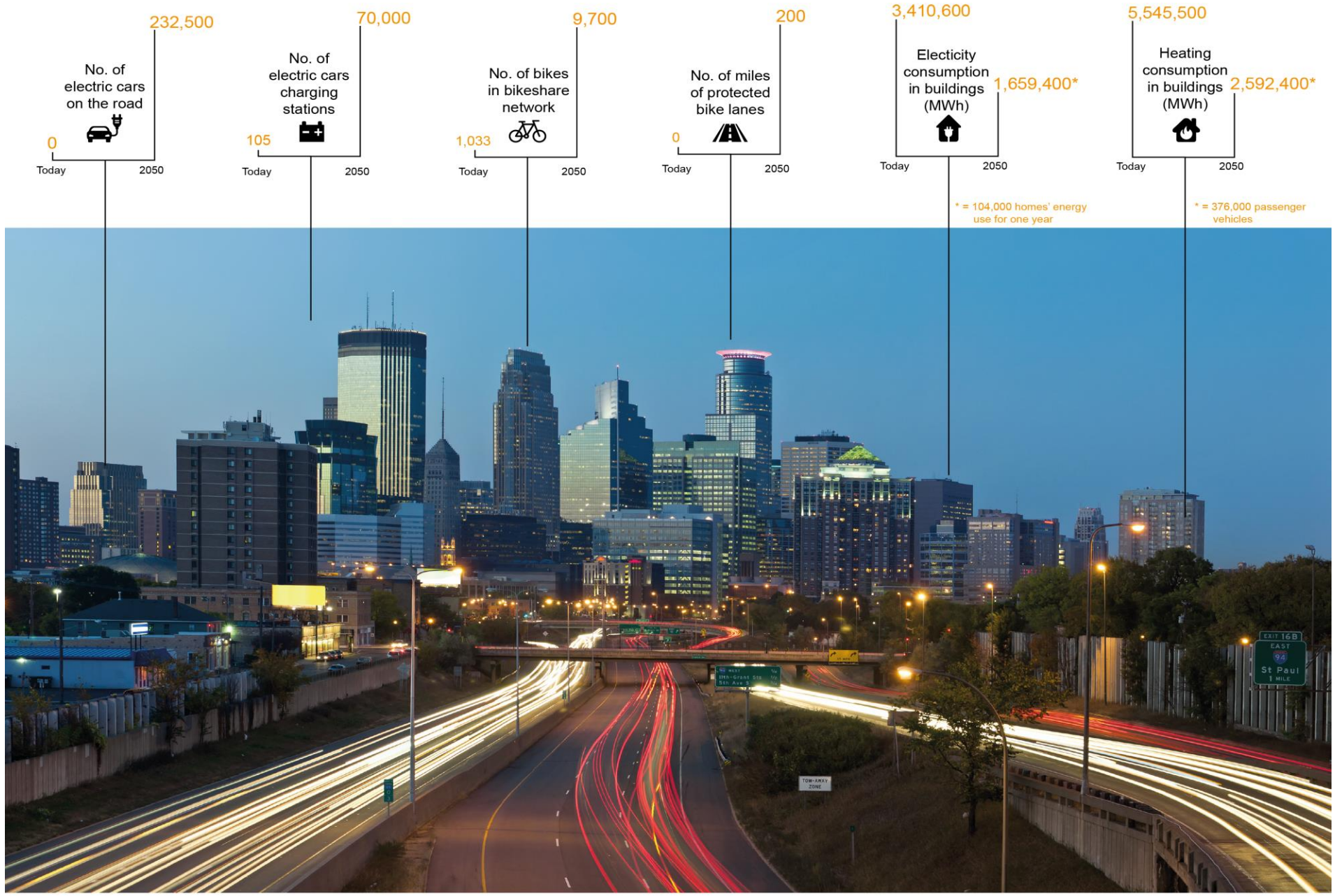
Number of Charging Stations Per Electric Car



In 2050…

MINNEAPOLIS ‘80 BY 50’

Based on these strategies, this is what 2050 will look like...



In 2050…

+ 230,000 eCars

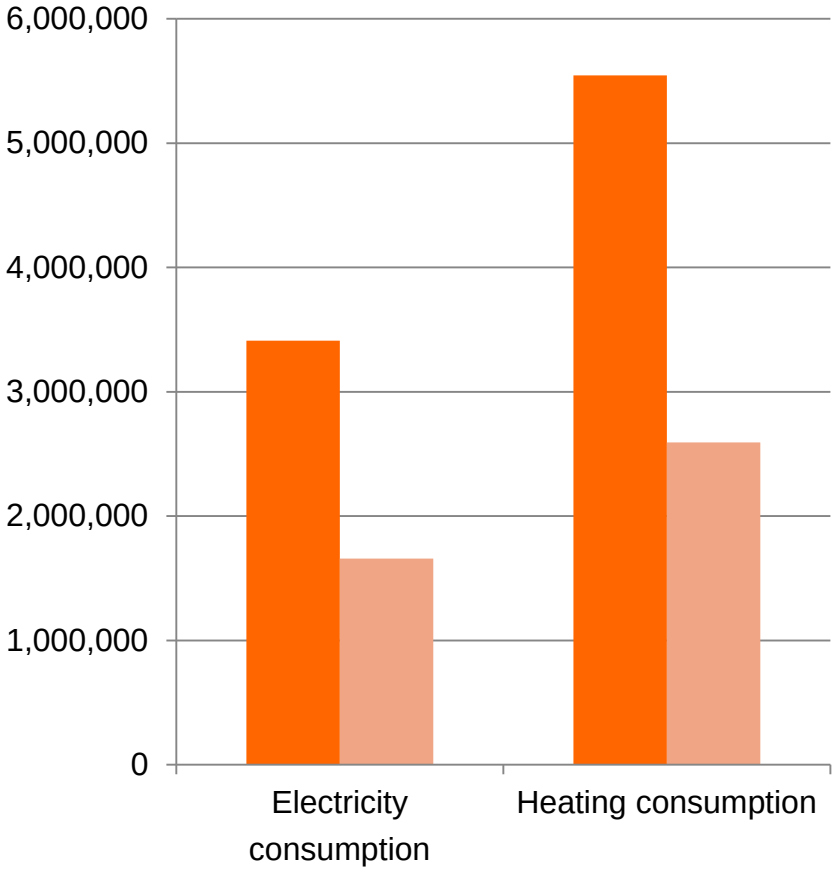
+ 70,000 Charging Stations

+ 125 miles Protected Bike Lanes

53% reduction in building heat demand

51% reduction in building electricity demand

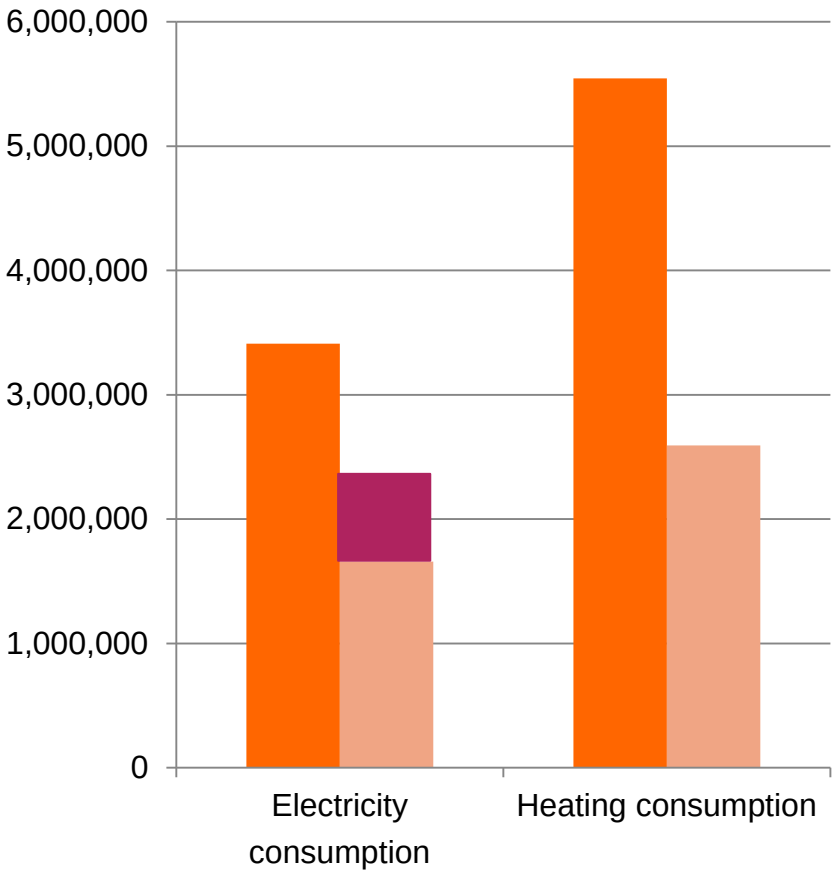
In 2050…



Difference in Electricity and Heating Consumption by Buildings, Today v. 2050
(in MWh)

Electricity Consumption: Using average 2015 electricity prices in Minnesota (kWh=$0.11) Annual savings are equal to $337.5M

In 2050…



Difference in Electricity and Heating Consumption by Buildings + Increase in Electricity Consumption by Transport, Today v. 2050
(in MWh)

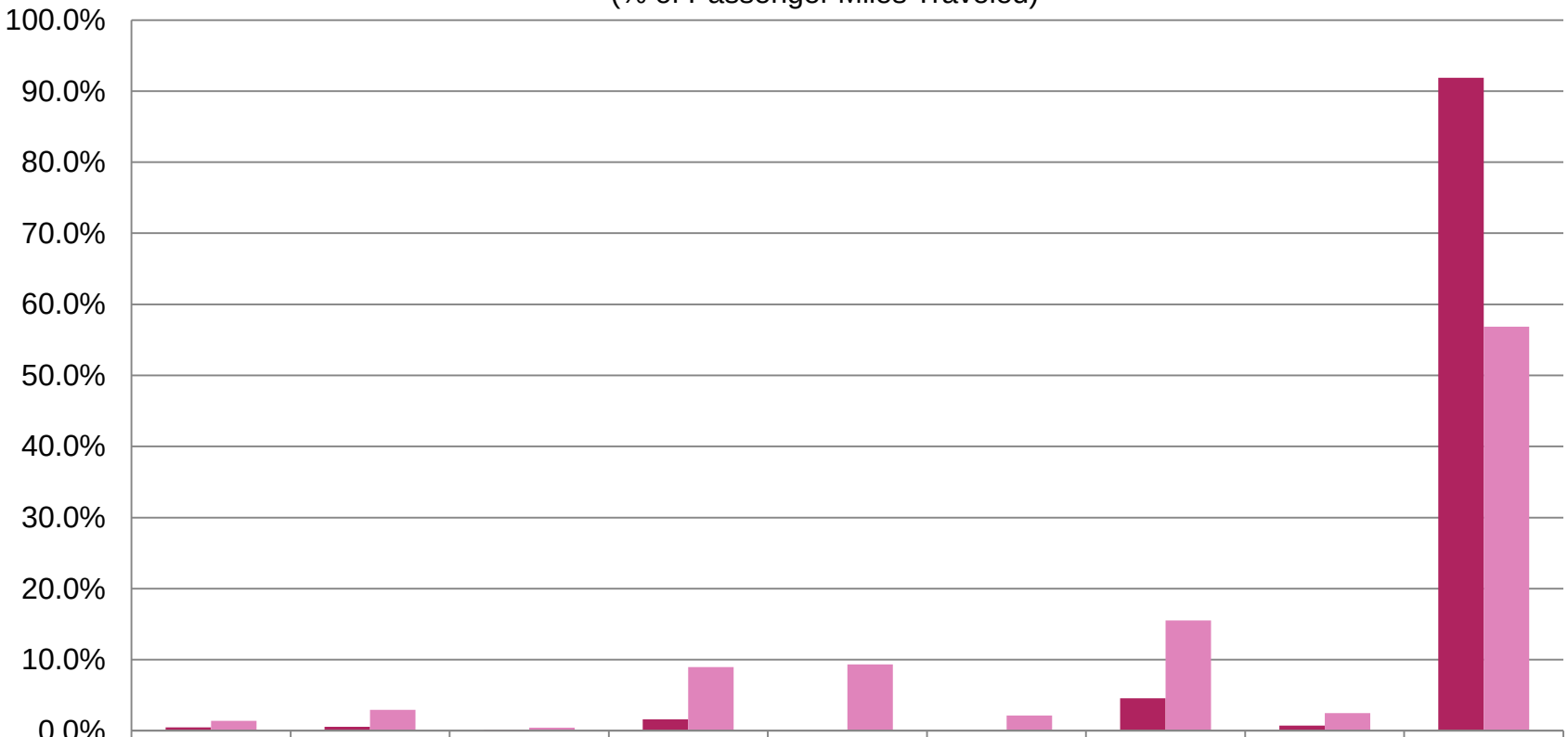
2015
2050

With implementation of electric cars and electric forms of public transport, electricity consumption from transport will increase by 884,500 MWh

In 2050…

Mode Share for Passenger Transport

(% of Passenger Miles Traveled)



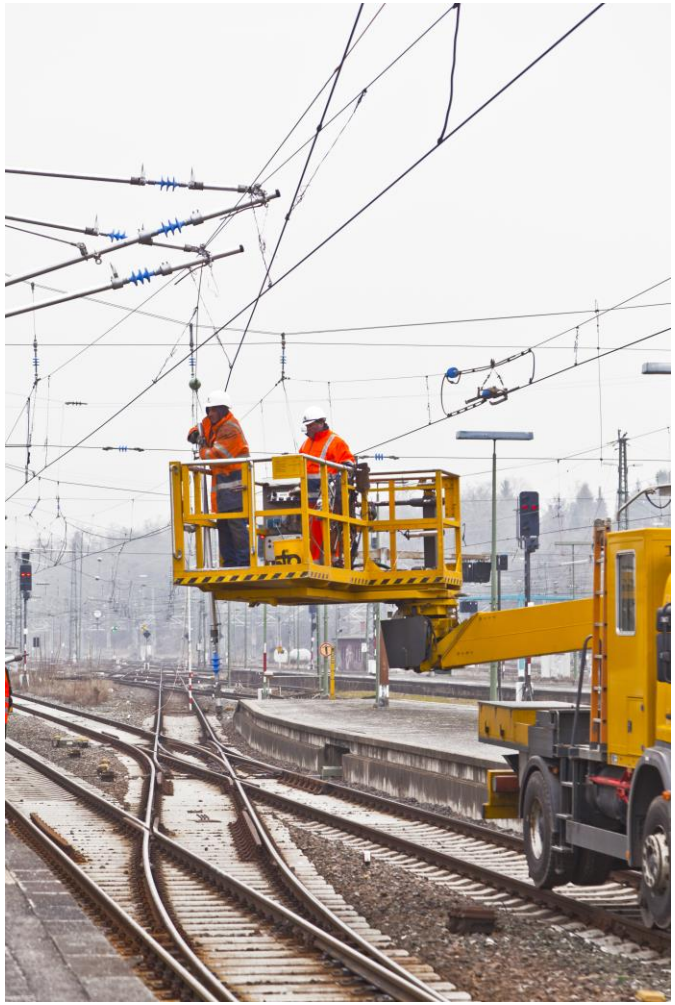
	Walking	Cycling	Commuter Rail	LRT	Street Car	BRT	Bus	Taxi	Car
2015	0.5%	0.6%	0.2%	1.6%	0.0%	0.0%	4.6%	0.7%	91.9%
2050	1.4%	2.9%	0.4%	9.0%	9.3%	2.1%	15.5%	2.5%	56.8%

APPENDIX

Xcel Scenarios and Emissions Factors

			NSP system CO2 rate (lbs CO2/MWh)			
Scenario #	Scenario family	Description	2015	2020	2025	2030
10	Preferred Plan	Wind + Solar	1,047	861	802	720
10B	Preferred Plan	Wind + Solar + Retire SH 1 2025	1,047	861	808	620
10F	Preferred Plan	Wind + Solar + Retire SH 1 2020, SH2 2023	1,047	861	593	518
10G	Preferred Plan	Wind + Solar + Retire SH 1 2025, SH2 2025	1,047	861	808	497
2	Retire SH1 (Retire SH1 YE2025, SH2 YE2030)	Replace: CC	1,047	886	955	798
5C	Retire SH1 (Retire SH1 YE2025, SH2 YE2030)	Replace 75% Renew: CT + Wind + Solar + DSM	1,047	875	943	745
6	Retire Both Units (Retire SH1 YE2025, SH2 YE2025)	Replace: CC	1,047	886	955	676
9C	Retire Both Units (Retire SH1 YE2025, SH2 YE2025)	Replace 75% Renew: CT + Wind + Solar + DSM	1,047	875	943	555
16	Retire SH1 (Retire SH1 YE2020, SH2 YE2030)	Replace: CC	1,047	886	825	798
19C	Retire SH1 (Retire SH1 YE2020, SH2 YE2030)	Replace 75% Renew: CT + Wind + Solar + DSM	1,047	875	754	745
24	Retire Both Units (Retire SH1 YE2020, SH2 YE2023)	Replace: CC	1,047	886	698	676
27C	Retire Both Units (Retire SH1 YE2020, SH2 YE2023)	Replace 75% Renew: CT + Wind + Solar + DSM	1,047	875	560	555

Overview of Methodology for Calculating FTEs



- Full-time equivalents (FTEs)
- Direct, indirect and induced jobs
- Associated with installation, operation, and maintenance of infrastructure
- *Gross*, not net, job creation
- Estimates based on:
  - Top-down studies of infrastructure investments in the US
  - Bottom-up figures from Siemens experience

Example of FTE Calculation for New Metro Lines

5 New Metro Lines

Ca.246,400 FTEs over 35 years = 7,040 on an annual basis

- 41% = local worker
- 27% = technician
- 32% = highly skilled

Combination of Capital Expenditures and Operational Expenditures

- CapEx for employment calculation is estimated to be 60% of total CapEx spend to remove any jobs linked to vehicle production
- CapEx jobs are estimated based upon the length and cost of the proposed line. Number of jobs per miles of track built.
- OpEx jobs are calculated based upon the number of miles of operating rail
- Assuming a 35 year build cycle, with part of the line open and running in year 2
- Year 1 only CapEx jobs included in estimation (ca.3% of rail track to be delivered). No OpEx
- Year 2 Construction continues with ca. 6% complete at year end and OpEx included based upon the ca.3% of rail line open.

Low Emissions Zone Freight Transport

- A road, network of roads, or geographical area where entry of freight vehicles or driving within is restricted according to exhaust emission standards

Overall city area is included in the low emissions zone restricting the freight vehicles below EUROclass 6 or equal

Reductions in annual emissions from today to 2050:

CO2e – 2,645 mt (0.07%)

NOx – 228,000 kg (5%)

PM10 – 11,000 kg (2.8%)

Jobs Created

195 jobs

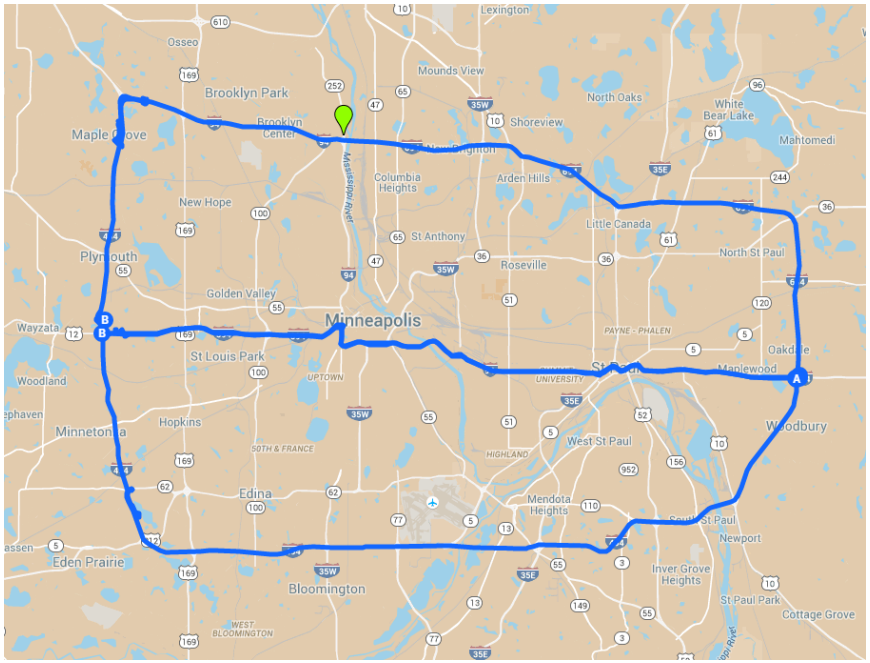
(72% semi-skilled)

$190,000 Cost per Job

(CapEx and OpEx are for detection and enforcement equipment)

Low Emissions Zone

- Restrict ‘dirty’ trucks from the downtown interstate routes
- Minneapolis has alternative fast routes around the city, which could absorb any additional traffic flow
- Overall aim is to shift the market and improve the fleet of trucks delivering to Minneapolis



Facts Related to Buildings-Related Energy Savings

Annual electricity savings in buildings equal to the consumption of 166,099 homes

Annual heat savings in buildings equal to the consumption of 185,000 homes

Total energy savings in buildings equal to 3.4 billion pounds of coal

Total energy savings in buildings equal to 85% of a coal fired power plant