Analysis of the Economic, Environmental, and Public Health Impact and Potential Revenues in the State of Minnesota

associated with the

Midwestern Greenhouse Gas Reduction Accord

August 30, 2010

Outline

- Introduction and Background
- Study Approach
- Economic Impacts Analysis
- Health Benefits Impacts
- Summary & Conclusions
- Appendices
  - Appendix A: Minnesota Green Solutions Act of 2008
  - Appendix B: REMI Results, Supplemental Cases

Introduction and Background

Introduction

- This study – commissioned in response to the Minnesota State Legislature request as reflected in the *Green Solutions Act of 2008* (see S.F. No. 2818, 6th Engrossment - 85th Legislative Session (2007-2008)) – examines the impacts of the *Midwest Greenhouse Gas Reduction Accord* (the *Midwestern Accord*) on the State of Minnesota.
- The goal of this study was to respond to the directives of the Green Solutions Act (GSA) by examining the Minnesota-specific impacts of measures to reduce greenhouse gas (GHG) emissions in the Midwest region as embodied in the Midwestern Accord.
- This briefing provides background on the study goals and objectives, and summarizes the analytic approach and the results.

The Midwest GHG Reduction Accord

- In November 2007 the *Midwest Energy Security and Climate Stewardship Summit* was held by the Midwestern Governors Association (MGA).
  - At the end of the two day Summit, six Midwest Governors – Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin – and the Premier of Manitoba signed the Midwestern Greenhouse Gas Reduction Accord. Indiana, South Dakota, Ohio, and Ontario signed the agreement as observers to participate in the formation of the regional cap-and-trade.
- The Accord members agreed to
  - Establish greenhouse gas (GHG) reduction targets and timeframes consistent with Midwestern Accord member states' targets.
  - Develop a market-based and multi-sector cap-and-trade mechanism to help achieve the GHG emissions reduction goals.
  - Establish a system to enable tracking, management, and crediting for entities that reduce greenhouse gas emissions.
  - Develop and implement additional steps as needed to achieve the reduction targets, such as a low-carbon fuel standards and regional incentives and funding mechanisms.

Draft Recommendations of the Advisory Group

- In November 2008, the Accord Advisory Group made a series of recommendations to guide further discussions and analysis of the Accord. These included the recommendation to establish a regional cap-and-trade that required reductions in GHG emissions of
  - 15, 20, or 25 percent below 2005 levels by 2020
  - 60-80 percent below 2005 levels by 2050
- It was recommended the program cover the following sectors
  - Electricity generation and imports
  - Industrial combustion sources
  - Industrial process sources (to the extent credible measurement & monitoring protocols exist or can be developed prior to inclusion)
  - Transportation fuels
  - Fuels serving residential, commercial and industrial buildings not otherwise covered
- The recommendations assume that other Complementary policies will be implemented to ensure that comparable reductions will be achieved in those sectors not recommended to be part of the cap-and-trade program so that, taken together, the cap-and-trade (C&T) program and the other policies will achieve the regional goal equitably across the economy.

Stewardship Platform-Complementary Policies

- To lower GHG emissions and transition to a lower carbon energy economy, the Accord identified the following goals for Complementary policies
  - Energy Efficiency Improvements – 2% of regional annual retail sales of natural gas and electricity by 2015, and additional 2% every year.
  - Bio-based Products and Transportation –Biofuels supplying 50% of the region's transportation fuels by 2025, including
    - Accelerating strategies for improving the efficiency of biofuels production and utilization
    - Reducing fossil fuel inputs
    - Minimizing GHG emissions
    - Decreasing water use; strengthening the existing biofuels industry
    - Developing, demonstrating and commercializing a variety of biomass-utilizing technologies and other low-carbon advanced fuels
  - Renewable Electricity –at least 30% of the region's electricity by 2030.
  - Advanced Coal and Carbon Capture and Storage (CCS) – By 2020 all new coal gasification and coal combustion plants will capture and store CO2 emissions.
- The “Platform Case” referenced throughout this document refers to those C&T targets and Complementary Policies viewed by the Advisory Group to be most likely to be adopted and described in the next section.

Minnesota Green Solution Act of 2008

- In November 2008, the Minnesota Legislature passed the Minnesota Green Solutions Act (S.F. # 2818) requesting additional analysis of and information on the Midwestern Accord.
- Specifically, the Legislature requested an analysis to determine the economic feasibility and impact of a Cap-and-Trade policy on the state as called for by the Accord.
- The Green Solutions Act (GSA) called for several analyses related to the Accord including
  1) A study of the economic, environmental, and public health impacts of the Accord (Section 3, subdivision 2 of the GSA)
  2) A study of the implications of alternative uses of revenues from the potential cap and trade program (Section 3, Subdivision 3)
- This study fulfills these two requirements of the GSA.

Minnesota Green Solution Act Requirements

- The specific requirements of Section 3 of the GSA included estimates of
  - Direct impacts – on investment requirements, energy costs, GHG emissions, and estimates of allowance prices.
  - Indirect Impacts – not incurred directly from the implementation of GHG reduction policies including impacts on jobs, households, industry, and other economic factors.
- The GSA also required two additional analyses
  - Health Impact Analysis - due to reduced emissions of criteria air pollutants cause by the GHG reduction policies.
  - Potential Revenue Analysis – on the impact of alternative uses of revenues generated from a Cap-and-Trade policy.

This Study Supplements the Analysis of the Midwestern Accord Commissioned by the MGA

- Many of the questions required to be answered by the GSA were examined by the study of the Midwestern Accord commissioned by the Midwest Governors Association (the "MGA Study" or the "Midwestern Accord Study").
- The Midwestern Accord study developed estimates of costs and allowance prices of various Cap-and-Trade policies for the Accord member states and provinces.
- The study was completed under the direction of the Advisory Group and Modeling Subgroup. The full reports are available online and links to them are shown on the next page.
- This study of Minnesota-specific impacts responding to the requirements of the Green Solutions Act relies on the assumptions, data and modeling tools used in the Midwestern Accord analysis. ICF completed both studies.
- It is important to note that while this study focuses on impacts on the state of Minnesota, it models a regional GHG C&T program affecting the Accord Members. No Minnesota-only cap-and-trade policy is modeled.

Midwestern Accord Study Results Briefings Are Available Online

Presentation	Website
IPM Final Modeling Results Presentation (May 2009)	http://www.midwesternaccord.org/Meeting%20material%20pages/GHG-meeting-10/MGGRA_Modeling_Results.pdf
Detailed Presentation on REMI Modeling Results (March 2010)	http://www.midwesternaccord.org/Presentation.pdf
REMI Modeling Results Summary (April 2010)	http://www.midwesternaccord.org/Modeling_Summary.pdf

Minnesota Economic Analysis Study Approach

Midwestern Accord Analysis was the Starting Point

- The Midwestern Accord Advisory Group commissioned a study of the economic impacts of the Accord, including an analysis of the Complementary policies and the Cap-and-Trade policies.
- ICF was selected to perform the Midwestern Accord study. The study was guided by the Modeling Subgroup of the Accord Advisory Group.
- Over a period of several months and nearly a dozen meetings, the Modeling Subgroup reviewed the overall study approach and developed key assumptions required by the modeling.
- Final modeling assumptions included electricity demand; availability, costs and operating performance of new technologies; fuel prices; availability of offsets; availability of energy efficiency; and representation of complementary policies, including low-carbon fuel standard, Renewable Portfolio Standards (RPS), and implementation of regional goals for advanced coal with CCS.

Midwest GHG Accord Analysis, cont.

- Two modeling frameworks were used in the analysis of the Midwestern Accord
  - IPM® – A multi-sector model representing the U.S. and Canada, with very detailed information representing the power sector, was used to analyze the direct impacts of the complementary policies on the Midwest. IPM was also used to analyze the energy and emissions effects of the Cap-and-Trade policy and other GHG C&T policies considered by the Accord.
  - Policy Insight+ (PI+ or "the REMI Model") – a structural economic forecasting and policy analysis model developed by Regional Economic Models, Inc. (REMI), that integrates input-output, computable general equilibrium, econometric, and economic geography methodologies, was used to assess the regional economic impacts at the member-state level.
- The geographic scope of the IPM modeling was the U.S. Midwest and Canada, to accommodate all Accord members. Geographic scope of the REMI modeling included only US states, since the REMI model did not include Canadian provinces, when this study was commenced.

Minnesota Study Approach

- The Minnesota study was based on the Midwestern Accord analysis which analyzed power and sectoral impacts of a regional cap-and-trade and other GHG reduction policies. As noted, although the focus was state-level impacts, no state-only C&T policy was analyzed.
- This study uses Accord policy scenarios to assess the potential direct impacts of a cap-and-trade and other policies using the following modeling programs
  - IPM® and the REMI Model, described previously
  - CALPUFF – an air quality model to assess long range transport of pollutants
  - BenMAP – a benefit mapping and analysis program to assess health impacts
- The Minnesota analysis also used the REMI model, but divided Minnesota into two regions for a more detailed analysis.
- The Minnesota study was extended to address specific requirements of the Green Solutions Act. Therefore, additional analyses were completed, including detailed revenue expenditure analyses and distributional impacts.

Stakeholder Process Guided the Modeling

- ICF implemented the analysis with input from Minnesota Department of Commerce and the Minnesota Pollution Control Agency, as well as the Minnesota stakeholders who participated in the Midwestern Accord process.
- Numerous calls were held to review the Study's scope and approach, key assumptions, scenarios, and results.

Modeling Tools Used in the Study

- The **Integrated Planning Model (IPM®)** is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. Key features of IPM include
  - Least-cost capacity expansion and electricity dispatch
  - Optimal emission control strategies for meeting demand and emission constraints
  - Detailed forecasting of renewable resources, energy efficiency opportunities, and offsets
  - Endogenous treatment of fuel markets including coal, natural gas and biomass

  IPM was used to evaluate the cost and emissions impacts of proposed policies to limit emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and mercury (Hg). The IPM runs applied for this study were a subset of the runs developed for the Midwestern Accord Analysis.
- The **Policy Insight Model (PI+ or "the REMI Model")** is a dynamic economic forecasting model that generates simulations on an annual basis to include behavioral responses to wage, price, and other economic factors. The entire Midwest was modeled, with state-level detail for the Accord member states. Minnesota was divided into two regions for modeling purposes in REMI.
- **CALPUFF**: An advanced meteorological and air quality dispersion modeling system adopted by the U.S. EPA's Office of Air Quality Planning and Standards (OAQPS) as the preferred model for assessing long range transport of pollutants and their impacts.
- **BenMAP**: A modeling system developed by EPA/OAQPS to estimate national and regional benefits of air quality control programs. BenMAP provides estimates of changes in the risks of various health impacts and calculates the changes in health-related costs associated with changes in pollution levels.

Policy Modeling, Economic, and Public Health Results

- The next three sections summarize the results of the analyses conducted in response to the *Green Solutions Act*
  - Analysis of the Cap-and-Trade and Complementary Policies Modeling (using IPM) summarizes the impacts of the policies.
  - Economic Impact Analysis and Revenue Impacts Analysis using REMI examines four of the 14 cases run for the Midwestern Accord analysis.
  - Health Benefits Assessment presents the results of the analysis of the Complementary policies and C&T policies on mortality and morbidity in Minnesota.

Cap-and-Trade and Complementary Policies Modeling

Minnesota Study Builds Upon Midwestern Accord Study Results

- The Minnesota study begins with the Midwestern Accord study results
  - Four cases were selected from the approximately fourteen scenarios analyzed from the Midwestern Accord study as the basis of the analyses requested by the GSA with a detailed focus on Minnesota-specific impacts.
  - For the chosen subset of cases, additional details were extracted from the IPM results to support Minnesota-specific modeling.
- The REMI modeling used more detailed Minnesota-specific inputs and other state-level and regional inputs.
- Additional REMI runs were conducted to address the revenue impact requirements of GSA.

Four Scenarios from the Midwestern Accord Analysis Were Used

- Reference Case
  - The business-as-usual case which assumes no policy change.
  - Serves as a reference point against GHG reduction policy cases to determine the impacts of the complementary measures or C&T policies.
- Complementary Policy Case
  - Models the implementation of energy efficiency improvements, renewable portfolio standards (RPS), new coal with carbon capture and sequestration (CCS), and low-carbon fuel standards (LCFS) as defined by the Accord.
  - No explicit carbon limit.
- Platform Case with a First Jurisdictional Deliverer (FJD) Point of Regulation
  - This case assumes the Platform Case – Cap-and-Trade and Complementary Policies as defined by the Accord Draft Recommendations.
  - Approximates an FJD point of regulation.
- Cap-and-Trade Only Case
  - The implementation of a carbon cap-and-trade without Complementary policies in place.
  - The modeling framework identifies a least-cost mix of responses to the emissions limits, including renewables, energy efficiency, and system changes.

Key Parameters in the C&T Platform Case as Defined by the Draft Recommendations

Policy Run Parameter	Definition
Cap Level	20% below 2005 level by 2020; 80% below 2005 level by 2050; Emissions cap level straight-lined from start-year to 2020 and from 2020 to 2050
Geographic Scope	Accord Members Only (IA, IL, KS, MI, MN, WI, MB)
Sectors Under Cap	Electric Power, Industry, Transportation, Residential, and Commercial Coverage: Electric Power (>25 MW, 98%); Industry (100% via hybrid large-sources / upstream point of regulation)
Offsets	15% of cap in each year; 4/5's must originate in capped region; 1/5 of offsets from rest of U.S.
Complementary Policies	Included (2%/yr and 1%/yr EE savings variations)

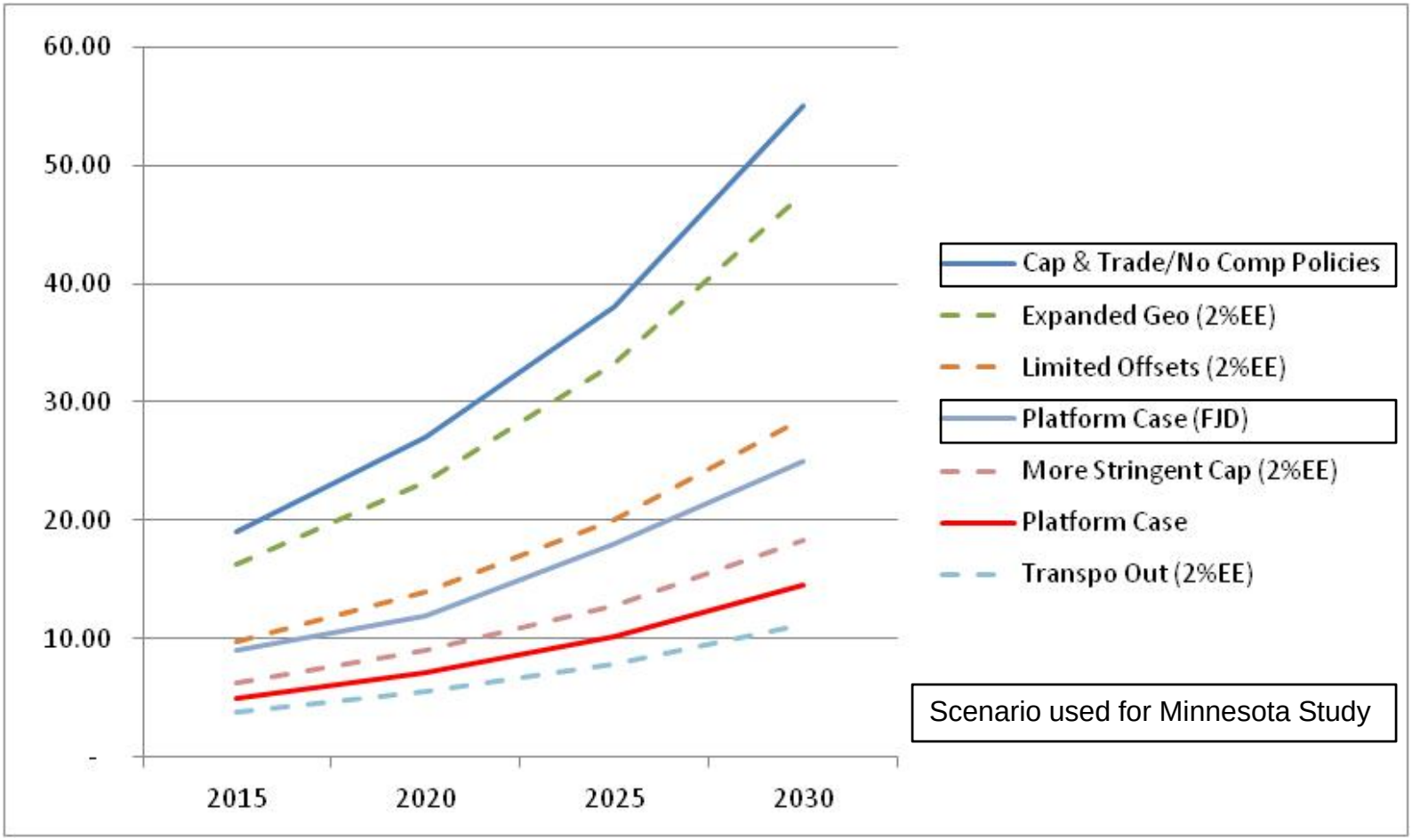
Complementary Policies and Treatment in the Modeling

Platform Theme	Measurable Goal	Modeling Approach
Energy Efficiency	2% / yr. EE savings for Electric & Natural Gas	Hard-wire reductions in demand Turn-off ICF's EE measures except in C&T Only policy run Run 1% / yr. EE sensitivity cases
Renewable Electricity	10% by 2015; 30% by 2030	Approximate MGA-wide RPS
Advanced Coal / Carbon Capture and Storage	2012: Regulations and pipeline 2015: 6 plants w/CCS 2020: No new coal w/o CCS 2050: Coal fleet transitioned	CCS on Duke Edwardsport plant Require 1,200 additional MW of IGCC+CCS and one PC retrofit Post-2020 ban on new coal without CCS CCS retrofit option included in model
Bio-based Products and Transportation	Low Carbon Fuel Standard in place of Platform goals—10% intensity reduction within 10 years	Approximate LCFS compliance via traditional and cellulosic biofuels ramp-up Biofuels outside the cap

Modeling Results – Projected Allowance Prices

- For the Midwestern Accord study many alternative cases and sensitivities were run. The results for selected cases – in terms of regional allowance prices ($/ton of CO2) – are shown in the next slide.
- The two Cap-and-Trade cases used in the Minnesota analysis are highlighted.

Regional Allowance Prices under Various C&T Scenarios Modeled



IPM Outputs were Inputs to REMI and CALPUFF Models

- Outputs from the IPM model for each of the cases were used as inputs for the REMI economic analysis.
- Generally, outputs were developed at the state level for member states, and the rest of MGA. For Minnesota, outputs were further divided into two regions: the 11-county Twin Cities area and the rest of Minnesota.
- The CALPUFF modeling framework used the disaggregated changes in SO_2 and NO_x emissions from the IPM policy cases to simulate air quality changes and resulting health impacts.

IPM Outputs used in the REMI and CALPUFF Modeling

- The IPM model results included the following key outputs
  - Energy prices for all fuels including electricity, natural gas, coal and biomass.
  - Investments in electric generating capacity by fuel and technology for the energy market including new generation and retrofits.
  - Retirements of electric generating capacity.
  - Emissions from electric generation including CO_2, NO_x, and SO_2; and emissions of CO_2 for industrial, commercial, residential, and transportation sectors.
  - Costs incurred by the policy cases from production costs, offset purchases, and allowance prices.

REMI Scenarios

- Four scenarios were modeled in REMI (both for the Midwestern Accord and Minnesota-specific studies)
  - Reference Case – Business-as-usual
  - Complementary Policy Case – Includes Complementary policies only
  - Platform Case – Both Complementary policies and Cap-and-Trade policy
    - Various revenue recycling options modeled
  - Cap-and-Trade Only Case
    - Various revenue recycling options modeled

Economic Impact Analysis

Introduction

- Goal is to study the economic impacts of the proposed Midwestern Accord on Minnesota regions
  - Determine the overall economic impacts of the Accord on Minnesota residents.
  - Estimate the costs of the program in terms of employment and economic output (Gross Regional Product or GRP) on Minnesota businesses and workers.
- Focus is on studying how the allowance revenues can be used effectively to mitigate the costs of the program
  - Analyze various options for recycling allowance revenues and determine the best use of revenues to minimize costs.
  - Identify which revenue recycling options may be more effective in helping businesses and residents in adapting to the Accord provisions.

Methodology

Framework

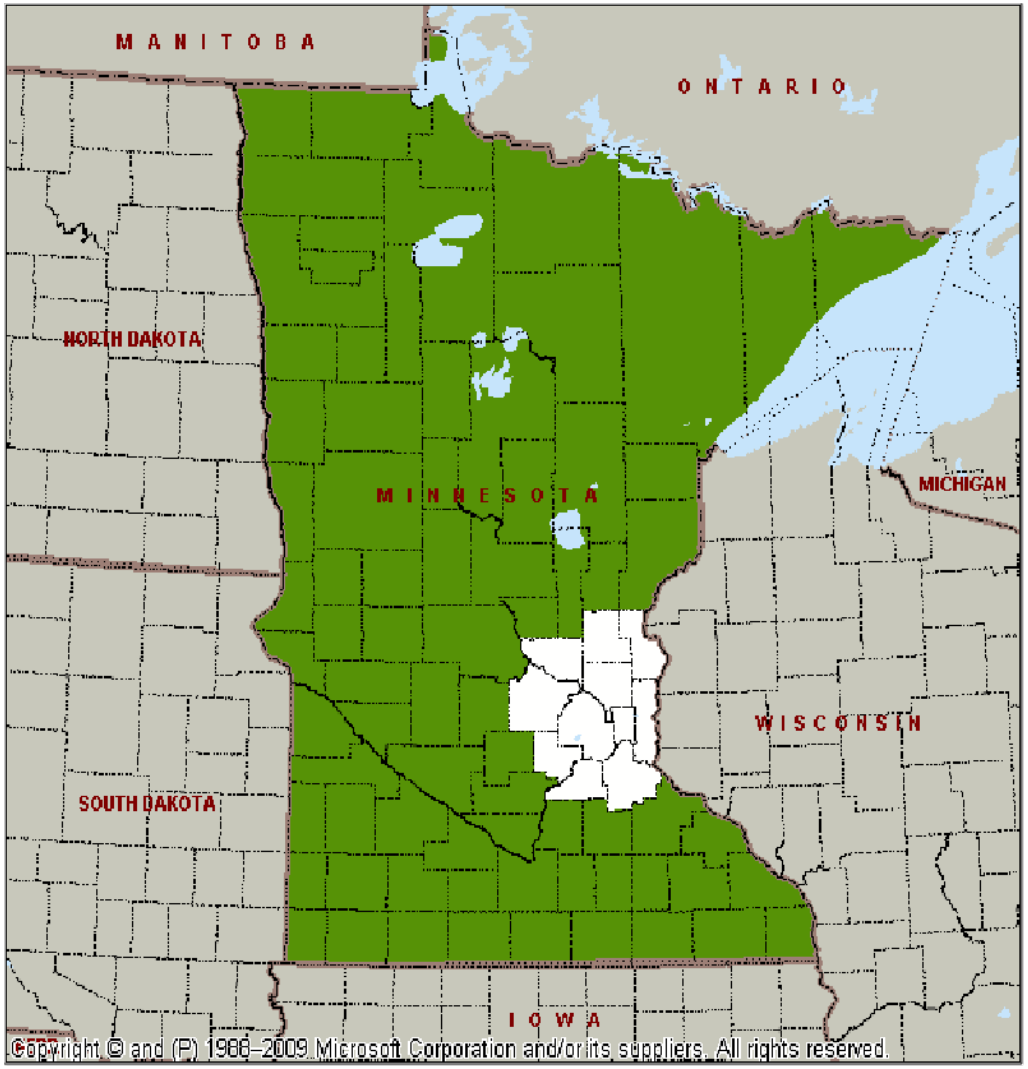
- Regional Economic Models, Inc. (REMI) Policy Insight Plus was used to model the macroeconomic impacts, using results from IPM modeling conducted for various policies.
- REMI is a *dynamic* regional economic impact model using a combination of input-output, econometric, and computable general equilibrium (CGE) modeling techniques
  - Provides the ability to forecast impacts over time
  - In this study, results are presented up to 2030
- Output options in REMI – all standard outputs and high resolution in sector and regional breakdowns
  - Provides the ability to analyze distributional impacts across regions and affected groups.

Modeling Regions

- We used the same REMI PI+ model that was used for the Midwestern Accord study
  - Model included a total of 12 regions broken down in the following way
    - 5 Midwestern Accord Member states (all US, excluding Minnesota)
    - 3 Accord Observer states (all US)
    - Minnesota, broken down into two sub-regions (see map on next page).
    - Rest of Midwest (3 states)
    - Rest of US

Breakdown of Minnesota Regions in REMI

Twin Cities
Anoka
Carver
Chicago
Dakota
Hennepin
Isanti
Ramsey
Scott
Sherburne
Washington
Wright
Rest of MN
76 Remaining Counties



Inputs Used in REMI Modeling

- IPM outputs used in REMI include
  - Changes in energy prices (electricity and fuel)
  - Capital and O&M expenditures for new units (e.g., IGCC), retrofits (e.g., CCS on coal), and renewables
  - Expenditures on energy efficiency policies and low carbon fuel standards (LCFS)
  - Bill savings from energy efficiency programs
  - Early plant retirements
  - Allowance prices and allowance revenue amounts
  - Allowance positions of different sectors (e.g., allocated vs. auctioned allowances)
  - Offsets positions (sectors buying and selling offsets)
- Where necessary, additional inputs from other sources were used to supplement (for e.g., impacts of the Low Carbon Fuel Standard from the MGA Energy Choice Simulator).

Modeling Complementary Policies in REMI

- Energy Efficiency (EE)
  - Net economic impact (or "unit costs" per KWh saved for the three types of EE programs) came from the Energy Efficiency Advisory Group (EEAG) work for the Midwestern Accord analyses
    - Assumed 3¢/kWh net economic impact for utility programs; lower estimates for public sector lead by example and building codes.
    - These estimates were then multiplied with the estimated KWh saved to determine the total economic impact potential.
  - REMI inputs divided among manufacturing subsectors, construction, and retail sales
    - Economic sectors for various programs were identified from various studies, including several from the American Council for an Energy-Efficient Economy (ACEEE).

Modeling Complementary Policies in REMI, cont'd.

- Low Carbon Fuel Standard
  - Used data from the MGA Energy Choice Simulator
  - Investments needed to reduce fuel carbon content (e.g., additional refining capacity and distribution systems) were divided between construction and petroleum refining sectors
  - Estimated changes in fuel prices (at the pump) were also included
- Renewable Portfolio Standards (RPS) and Carbon Capture and Sequestration (CCS) – billions of dollars required for investment in new technologies, especially in CCS in the early years
  - REMI inputs were divided between construction and manufacturing sectors
  - CCS requirements in the early years also led to higher electricity prices for different customer classes
- In general, all of these Complementary policies had significant positive economic effects as well as some negative effects, primarily due to higher energy prices. Expenditures on these policies are shown below.

Investments in Comp Policies in the Complementary Policy Run ($MM)*

	2015	2020	2025	2030
Twin Cities				
Energy Efficiency	145	306	461	609
LCFS	180	270	75	23
Rest of MN				
Energy Efficiency	94	192	284	369
LCFS	116	169	46	14
Renewables	--	73	131	144
Rest of Midwestern Accord Member States				
Energy Efficiency	1,333	2,948	4,480	5,920
LCFS	1,257	1,739	735	221
Renewables	--	430	821	943
CCS	1,206	29	54	64

*** Incremental Over the Reference Case**

- **While there were no clean coal with CCS plants being sited in MN, we assumed electricity rates for MN residents would reflect the costs of building CCS in the Midwestern region due to the Accord.**

Scenarios Modeled in REMI

- All Runs were modeled using the same method as was used in the Midwestern Accord modeling scenarios
  - However, some of the Minnesota sub-regional inputs in REMI were adjusted to reflect inter-regional differences, such as differences in retail electricity prices, early plant retirements, etc.
  - Also accounted for significant regional shifts in capital expenditures on renewable new builds
    - All investments are now mapped to the Rest of MN region in REMI.
  - Scenarios modeled in REMI
    - Reference Case
    - Complementary Policy Case
    - Platform Case
    - Cap-and-Trade Only Case

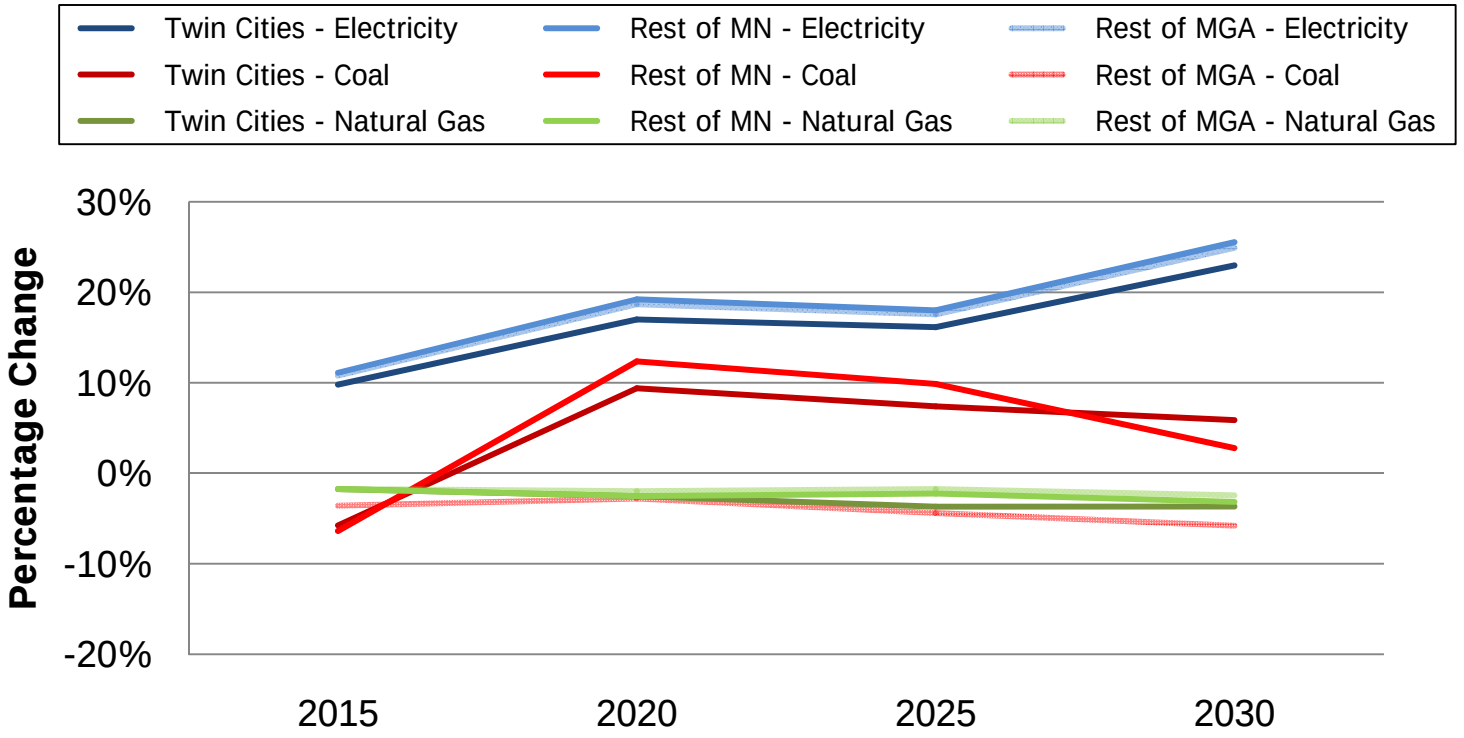
Revenue Expenditure Impact Scenarios

- Under the Platform Case (as well as the Cap-and-Trade Only Case), we modeled six different revenue recycling impact scenarios, per the guidance in the GSA, along with an additional no revenue recycling scenario (this last scenario provides a basis for comparison with the overall Midwestern Accord runs). More details on these options are provided in the next section.

  1. **Per Capita Rebates –** Lump sum, direct per–capita rebates to all Minnesotans
  2. **Consumer Incentives –** Grants or incentives to consumers to encourage investment in energy efficiency or renewable technologies that help reduce energy costs and consumption for Minnesotans.
  3. **Business Incentives –** Financial incentives for businesses to install GHG reducing technologies, focusing primarily on energy-intensive industries.
  4. **Public Infrastructure –** Investments in public infrastructure designed to reduce GHG emissions.
  5. **Worker Retraining –** Investment in retraining of workers who lost their job, as well as financial incentives to business for hiring newly trained workers.
  6. **Hybrid –** Allowance revenues are split equally between Consumer Incentives, Business Incentives, Public Infrastructure Investment and Worker Retraining programs.

- **No Revenue Recycling –** worst-case scenario in which allowance revenues are not used for mitigating policy impacts.

Percentage Change in Non-Transportation Fuel Prices for the Platform Case, Relative to the Reference Case



Note: The graph above accounts for non-transportation fuels only (from IPM). Gasoline prices were modeled separately and were estimated to increase 5%-10% in early years and about 1%-3% in later years, due mainly to LCFS.

Allowance Revenues ($ Million)

- Both the Platform Case and the Cap-and-Trade Only Case are likely to generate significant resources in allowance revenues through allowance auctions and fixed fees.

	Platform		Cap and Trade	
	2020	**2030**	**2020**	**2030**
Twin Cities	391	849	710	1,808
Rest of MN	245	514	445	1,094
Total	**636**	**1,363**	**1,155**	**2,902**

  - For the Platform Case, revenue amounts range from over $600 million/year in 2020 to over $1.3 billion/year in 2030.
  - For the pure Cap-and-Trade Case, revenue amounts range from over $1.1 billion in 2020 to almost $3 billion in 2030.

Economic Impacts: Modeling Results

Road Map of the REMI Results Discussion

- Modeling results are discussed in the following order
  - For each revenue impact scenario
    - The first section provides a table with the summary results for employment and GRP in 2020 and 2030 (incremental from Reference Case), along with our discussion on modeling approach and input data, etc.
    - The second section provides a more detailed comparison of the impacts across the different options to understand how they rank in terms of mitigating impacts.
  - All results discussed in the main briefing are for the Platform Case. Results for the Cap-and-Trade Only Case are discussed in detail in Appendix B, and a brief summary of those findings are presented at the end of the main briefing.

Complementary Policy: Summary Results, 2020, 2030

Complementary Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.17%	0.25%	-0.25%	0.14%
Twin Cites	-0.23%	0.15%	-0.28%	0.07%
Rest of MN	-0.07%	0.43%	-0.15%	0.38%
Rest of Midwestern Accord Members	-0.18%	0.34%	-0.23%	0.28%
Rest of Midwest	-0.28%	0.24%	-0.33%	0.16%

*** Relative to the Reference Case**

Complementary Policy: Summary Results Discussion

- Complementary policies lead to some short-term pains but long-term gains.
  - Impacts in 2020 are expected to be slightly negative, for both Minnesota regions, due primarily to higher electricity prices from the CCS requirements under the Midwestern Accord.
  - Twin Cities will have higher impacts than the rest of MN because of relatively higher energy prices and rest of MN also benefits from high levels of investments in Complementary policies locally.
- By 2030, Complementary policies help create positive impacts for both Minnesota regions and lead to higher GRP and job gains, relative to the Reference Case (see next slide).

Complementary Policy: Summary Results Discussion, cont.

- By 2030, the suite of Complementary policies are expected to create over ten thousand jobs in Minnesota
  - Of which, four thousand jobs are estimated for the Twin Cities area and another six thousand in the rest of MN (see table).

	Employment (Thousands)	GRP ($ Billions)
Twin Cities	4.1	0.2
Rest MN	6.2	0.4
Rest Accord	72.4	6.0

- The positive benefits in the long run are mainly driven by the over $1 billion/year spent on Complementary policies in Minnesota
  - Over 50% of this amount is for the energy efficiency programs, rest split between renewables and LCFS infrastructure needs.
  - Expenditures are roughly evenly split between the Twin Cities and rest of MN regions (see slide 38).
- In the Rest of Accord Member states (i.e., excluding Minnesota), there could be over 72,000 additional jobs due to the Complementary policies, and 100,000 if we include Observers as well.

Modeling Various Revenue Expenditure Scenarios

1. Direct Per Capita Rebates to Minnesotans

- The Green Solutions Act (GSA) calls for using the allowance revenues to recycle as “direct per capita rebates to Minnesotans”.
- Modeling approach assumes lump sum transfer to all Minnesota residents
  - Similar to the Federal stimulus program.
- This approach tends to be more progressive than tax rebates, since tax rebates tend to favor higher income residents
  - As the table shows, households in Minnesota can get anywhere between $250/year to over $500/year annually from 2020 to 2030, if all allowance revenues are used for rebates.

Per Cap Rebates ($/Hh)		
	2020	**2030**
Twin Cities	$267	$525
Rest of MN	$273	$536

Per Capita Rebates: Summary Results

Platform - Per Capita Rebates Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.51%	-0.66%	-0.69%	-1.01%
Twin Cites	-0.65%	-0.90%	-0.76%	-1.17%
Rest of MN	-0.25%	-0.20%	-0.43%	-0.49%
Rest of Accord Members	-0.40%	-0.44%	-0.54%	-0.70%
Rest of Midwest	-0.42%	-0.27%	-0.49%	-0.39%

*** Relative to the Reference Case**

Rebates: Summary Results Discussion

- These results are very similar to the Platform "Best Case" scenario in the Midwestern Accord runs
  - For e.g., for the MGA study runs, employment drop for the "All Accord Member" region (i.e., including MN) were estimated to be -0.43% and -0.49% in 2020 and 2030, respectively; compared to -0.40% and -0.44% for Rest of Accord Members (i.e., excluding MN) for these runs.
  - GRP estimates were also slightly higher under the MGA study runs, with corresponding estimates for the applicable region (i.e., including MN) being -0.57% and -0.76% under the MGA study runs, as opposed to -0.54% and -0.70 in these runs (i.e., excluding MN), for 2020 and 2030, respectively.
  - Slight differences arise because of two reasons
    - Minnesota is separated out from what was the All Accord Member region in the prior runs, so the two regions compared here are slightly different.
    - Consequently, higher resolution of inputs used for the two Minnesota regions in these runs meant that there would be some spillover effects of these inputs on the other Midwestern states, thereby slightly improving the results for these neighboring states.

Rebates: Summary Results Discussion, cont.

- Results indicate that rebates can reduce costs of the Platform Case by about 20%-40% in terms of employment and GRP, from the no revenue recycling option
  - Rebates help mitigate impacts as residents go out and spend the money on their choice of goods and services, generating additional economic activity and employment.
  - Rebates are particularly helpful for low income residents who are likely to be hit the hardest by the program's effects on energy prices, etc. Note, although consumers face higher energy prices in general, that may not translate to higher energy expenditures because higher prices may lead to lower consumption, depending on the price elasticity of demand (thereby making the effect on total expenditures uncertain in this modeling exercise).
  - Some of the benefits of this option are likely to "leak out" of MN, since goods purchased in MN may have an out-of-state component.

2. Consumer Incentives

- Use allowance revenues to provide grants and incentives to consumers to invest in energy efficiency (EE) and utilize renewable energy (RE) sources to reduce energy costs and GHG emissions.
- Modeling approach assumes that the EE and RE programs would be funded through allowance revenues as opposed to rate increases (as was assumed for the MGA study runs)
  - Subtracted out costs of EE and RE programs from electricity prices for Minnesota only (funding for these programs for other states continue to come from rate increases).
  - Attached table shows the effect of these changes on electricity rates in MN regions compared to other states (incremental over the Reference Case). Because of the adjustments, rate increases in Minnesota are now slightly lower than other Accord states, since these programs do not need to be funded through rates any longer.

Increase in Retail Elec. Rates*		
	2020	**2030**
Twin Cities	15%	18%
Rest of MN	17%	20%
Rest of Accord	19%	25%

***Relative to Reference Case**

Consumer Incentive Investments ($ MM)

- In this study, we assume these EE/RE programs, under the Platform Case, are now funded through the available allowance revenues
  - Available allowance revenues adequately cover the entire funding needs for these programs (as shown in the table).
  - The two types of EE programs included were utility programs (EE-3) and building codes (EE-5), and the renewable new builds (for e.g., large scale wind and biomass plants). Proportion of funding needed for these three programs were estimated based on levels of investments determined under the MGA study runs.

	2020		2030	
	Twin Cities	Rest of MN	Twin Cities	Rest of MN
EE-3	262	165	564	342
EE-5	20	12	38	23
Renewable New Builds	0	177	0	184
Total	**282**	**354**	**602**	**548**

- Option is somewhat similar to providing rebates to consumers, but under this recycling option, the revenues are used in a more targeted fashion to mitigate the higher costs.
  - Goal is to see whether targeting energy efficiency and renewable energy programs with allowance revenue leads to more effective ways of reducing costs of mitigating climate change (in terms of better economic results compared to the previous option).

Consumer Incentives: Summary Results

Platform - Consumer Incentives Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.49%	-0.64%	-0.64%	-0.91%
Twin Cites	-0.61%	-0.83%	-0.70%	-1.03%
Rest of MN	-0.27%	-0.27%	-0.42%	-0.51%
Rest of Accord Members	-0.36%	-0.42%	-0.49%	-0.67%
Rest of Midwest	-0.38%	-0.25%	-0.45%	-0.37%

*** Relative to the Reference Case**

Consumer Incentives: Summary Results Discussion

- In general, results (employment and GRP) for the entire state are slightly better under this option compared to the previous option of providing "general" per capita rebates
  - This shows targeting allowance revenues for EE/RE programs may be marginally beneficial under our modeling assumptions.
- However, within Minnesota, the rest of Minnesota region appear to be slightly worse off under this scenario than under the per capita rebates. But the Twin Cities region is unambiguously better off, making the state-level results better off than per capita rebates.

3. Financial Assistance to Businesses

- GSA calls for providing financial assistance to businesses in the energy-intensive sectors that install technologies to reduce GHG emissions
  - Goal is to shield them from adverse competitiveness pressures from firms in states without similar caps on GHG emissions.
- Modeling approach was to first identify the energy-intensive sectors and give them free allowances to cover their emissions
  - Using MECS 2006, identified nine energy-intensive sectors (see table on next slide).
  - Assumed these sectors will not have to buy their share of the allowances (either auction or fixed fee) but will get them freely allocated, unlike the rest of the sectors that do not get free allowances.
  - Allocation shares for the energy-intensive sectors were determined, in part by the share of total allowances going to industrials and these nine sectors' emissions contributions within all industrial sectors. Consequently, their free allocations were less than their total emissions contributions, so the cap was still binding for these nine sectors.
  - Since these allowances have value, assumed a free allocation leads to increased shareholder value.
  - Because of their relatively small size in MN, these nine sectors only get 5%-8% of the total allowance revenues available. Remaining amounts are assumed to recycle back as rebates to consumers.

Financial Assistance to Businesses ($ MM)

Value of Allowances Allocated to Energy Intensive Sectors

	Twin Cities		Rest of MN	
	2020	**2030**	**2020**	**2030**
Mining (except oil and gas, includes taconite mining)	0.7	2.6	6.7	23.6
Wood product manufacturing	0.6	1.6	1.0	2.9
Nonmetallic mineral product manufacturing	0.4	1.2	0.6	2.0
Primary metal manufacturing	0.7	1.8	0.2	0.6
Fabricated metal product manufacturing	2.8	7.9	1.0	2.8
Food manufacturing	2.4	8.0	5.7	20.1
Paper manufacturing	1.0	2.7	0.7	2.0
Petroleum and coal product manufacturing	2.4	6.8	0.7	1.9
Chemical manufacturing	2.4	7.8	0.6	1.9
Totals	**13.4**	**40.4**	**17.2**	**57.8**

Business Assistance: Summary Results

Platform - Business Incentives Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.48%	-0.65%	-0.66%	-1.00%
Twin Cites	-0.62%	-0.89%	-0.73%	-1.16%
Rest of MN	-0.22%	-0.19%	-0.40%	-0.48%
Rest of Accord Members	-0.37%	-0.43%	-0.51%	-0.68%
Rest of Midwest	-0.39%	-0.26%	-0.46%	-0.38%

*** Relative to the Reference Case**

Summary Results Discussion

- Results for this option are similar, though slightly better than the per capita rebates option.
- This was expected since the only difference between these two options is the free allocation to the nine energy intensive sectors
  - As discussed above, these nine sectors had a relatively small footprint in Minnesota and their energy needs (and hence allowance needs) were small relative to the total size of the allowance market.
  - Most of the allowance needs were driven by the utility and transportation sectors
    - These two sectors are responsible for about 40% each of the total allowance values.
- Thus the competitiveness pressures on these nine energy-intensive sectors in Minnesota appear to be limited, vis-à-vis rest of the Accord member region.

4. Investments in Public Infrastructure

- Under this option, the GSA asks for using the allowance revenues for investments in public infrastructure projects to help reduce GHG emissions.
- Conducted research on Minnesota's public infrastructure needs and identified investment options consistent with our modeling approach and those that would reduce GHG emissions
  - Public Sector Lead by Example EE programs – based on the EEAG data, this required only about 1% of the available revenues.
  - Transportation infrastructure needs – remaining revenues were used for various transportation projects (see below for details).

Investment Needs for Infrastructure		
	2020	**2030**
LBE	8	12
Transportation	628	1,351
Total	**636**	**1,363**

Investments in Public Infrastructure

- Public Sector Lead by Example
  - This program could apply to buildings owned by the public sector or whose construction is fully/partially funded by the government.
  - We assume that a portion of the allowance revenues could be used to offset the costs of retrofitting buildings to reduce energy consumption (e.g., weatherization upgrades, use of energy efficient boilers, HVACs, etc.).
  - Assumed this program's effect on electricity rates (in the original MGA study REMI runs) was small and did not require adjustment for this study
    - In general, LBE contributed to only about 1% -2% of the total investments needed for all three types of EE programs, according to the EEAG data.

Investments in Public Infrastructure

- Transportation and transit infrastructure improvement
  - We assumed that the remaining allowance revenues could be used to fund the priority projects identified in the *2030 Transportation Policy Plan* conducted by the Metropolitan Council.
  - 2030 Transportation Policy Plan identified funding needs for
    - Highway improvement
    - Strategic transit expansion
    - Underfunded transit operation costs
    - Improve signage and safety of bike/pedestrian pathways to promote alternatives to driving alone.
  - Plan's focus is on funding needs for metro area, however, we assumed that these needs are proportionally applicable to the rest of the state, where appropriate (such as those for highway or signage improvement).

Investments in Public Infrastructure

Program	Cost
Highway improvement (reduce congestion)	2020 - $576M 2030 - $1.2B
Expand public transit options: Increased funding for bus and rail	
Promote alternatives to driving alone such as walking, biking (e.g. improve signage, safety, connections)	
Transit Operation (shortfall identified by 2030 Transportation Policy Plan)	2020 - $60M 2030 - $150M

- Specific cost data on the first three elements in the table above were not available, especially for investments needed to promote alternatives to driving. Because the funding needs for promoting driving alternatives were expected to be lower than the other two, using the best available data from the Transportation Plan, we assumed slightly more than half (54%) would be allocated to transit/driving alternatives and the remaining would be needed for highway improvements.

Investments in Public Infrastructure: Summary Results

Platform - Public Infrastructure Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.45%	-0.56%	-0.67%	-1.00%
Twin Cites	-0.59%	-0.80%	-0.74%	-1.15%
Rest of MN	-0.19%	-0.09%	-0.41%	-0.50%
Rest of Accord Members	-0.37%	-0.43%	-0.51%	-0.68%
Rest of Midwest	-0.39%	-0.26%	-0.46%	-0.38%

*** Relative to the Reference Case**

Summary Results Discussion

- Results for this option indicate that the overall impacts for the state, in terms of reducing the cost of the Platform Case, would be similar to the previous options, though slightly better
  - Effects on Gross Regional Product would be similar to the per capita rebates option, for the two MN regions separately, as well as in aggregate.
  - Employment impacts, however, are significantly better than the per capita rebates option (or the consumer incentives option), particularly in 2030. This is true for both MN regions, though the effect seems to be more pronounced for rest of Minnesota.
- Thus, using the allowance revenues to invest in infrastructure projects that reduce GHG emissions will have the added benefit of reducing the job losses caused by the cap-and-trade program under the Platform Case
  - Under our modeling assumptions, spending on infrastructure investments have a bigger "multiplier effect" on the state economy helping to sustain more jobs than handing out checks to consumers.

5. Worker Retraining

- Under the GSA, this option calls for using the allowance revenues to fund worker training and retraining programs and subsidize rehiring programs that target workers losing their jobs due to the cap-and-trade program.

Job Losses by Occupation Type		
	2020	**2030**
Twin Cities		
Blue Collar	6,216	10,229
White Collar	13,707	23,285
Rest of MN		
Blue Collar	2,042	3,075
White Collar	4,121	5,922

- To model this option, we first estimated the job losses by various occupational categories for our "worst case" scenario (no revenue recycling)
  - This provided a reference point for what the maximum job losses in Minnesota could be (see table).
  - Using occupational categories, as opposed to industry categories, provides a better assessment of the retraining needs and their associated costs.
- Using data from other states, identified job retraining programs and employee hiring incentive packages that could support rehiring, and identified costs associated with each program/package that could then be funded through the available allowance revenues (see details on next slide).

Worker Retraining

- We assume that Minnesota could use the available allowance revenues to offer the following three categories of retraining and two types of hiring incentives
  - Training
    - **Blue Collar Basic**: Provides general training for workers who may not have a broad base of manufacturing/building trade skills, includes soft-skills as well as a basic overview of trade skills.
    - **Blue Collar Technical**: Provides specific up-skilling for workers with some on-the-job experience in manufacturing or building trades.
    - **While Collar**: Provides sector-specific up-skilling related to management or content-specific skills.
  - Hiring Incentives
    - **One-the-Job Training (OJT) Subsidy**: Similar to National OJT program, provides subsidy for up to 60% of salary for first 6 months of employment while the newly hired worker gains experience.
    - **On-Boarding Subsidy**: DOL estimates that it costs a company roughly 1/3 of an worker's salary to bring them on-board. Subsidy offsets those costs to encourage hiring.

Retraining and Hiring Costs ($M)		
	2020	**2030**
Training Costs	43	65
Hiring Incentives	505	867
Total	**548**	**933**

Worker Retraining: Summary Results

Platform - Worker Training Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.41%	-0.54%	-0.42%	-0.69%
Twin Cites	-0.46%	-0.67%	-0.45%	-0.78%
Rest of MN	-0.31%	-0.29%	-0.31%	-0.40%
Rest of Accord Members	-0.37%	-0.42%	-0.50%	-0.68%
Rest of Midwest	-0.39%	-0.26%	-0.46%	-0.38%

*** Relative to the Reference Case**

Worker Training: Summary Results Discussion

- Among all the revenue recycling options studied so far, using the allowance revenues to retrain workers who lose their jobs to the Midwestern Accord and incentivize their rehiring, appears to be the most effective use of the resources
  - These programs can help reduce the job losses by about 40% - 50% from the worst case scenario (i.e., the maximum job losses estimated under the no revenue recycling scenario). Relative to the per capita rebates option, costs decrease by about 20% - 40%.
  - Since this option targets those who lose their jobs and provides them additional skills to get rehired, our modeling suggests this could be the most effective stand-alone option for using the allowance revenues.
- As more workers get rehired under this option, state economic output (GRP) losses are also minimized.

6. Hybrid Option

- The individual revenue recycling options discussed above allow us to "rank order" which ones could be more effective in reducing the costs of implementing a cap-and-trade program
  - But they do not allow looking at options that would allow the state to help multiple sectors (businesses, consumers, workers) simultaneously.
- Optimal way to use the allowance revenues would likely involve providing portions of the allowance revenues to multiple affected groups
  - Discussions of revenue recycling, both at the federal and regional levels, have centered around a combination or "hybrid" approach.
  - In a hybrid approach, available allowance revenues should be used to provide relief to multiple affected sectors.
  - The exact proportion of the allocation across various sectors would need to be determined.

Hybrid Option

- In our modeling, we assume that the total available allowance revenues (slide 42) is distributed equally across the four main options studied above
  - Consumer incentives – providing incentives to consumers to invest in energy efficient appliances. Our modeling approach assumes available allowance revenues can be used to fund utility programs (EE-3) and building codes (EE-5).
  - Business incentives – we assume the allocated allowance revenues are used to provide free allowances to nine energy intensive sectors. Rest of the allowance revenue share for this option is used to provide rebates to consumers, consistent with the assumption in the stand-alone modeling above.
  - Investing in public infrastructure – the allocated allowance revenues are used to fund public infrastructure projects.
  - Investing in worker retraining and re-hiring programs – the allocated allowance revenues are used to retrain workers who lose their jobs and provide hiring incentives to employers.

Hybrid Option

- We assume that the funding for these programs are proportionately reduced from the individual options discussed above, since each option is allocated one-fourth of the total allowance revenues
  - Funding is roughly $159 million/year per option in 2020 and about $341 million/year in 2030.
  - Used electricity rates from the consumer incentives run to account for the fact that partial funding for the energy efficiency programs would come from the allowance revenues available for hybrid consumer incentives.

Proposed Shares for Hybrid Run ($M)		
	2020	**2030**
Consumer Incentives	159	341
Business Incentives	159	341
Infrastructure	159	341
Worker Retraining	159	341
Total	**636**	**1,364**

Hybrid: Summary Results

Platform - Hybrid Option Policy Impacts*				
	Employment		GRP	
	2020	2030	2020	2030
All Minnesota	-0.34%	-0.29%	-0.27%	-0.35%
Twin Cites	-0.39%	-0.41%	-0.29%	-0.43%
Rest of MN	-0.25%	-0.08%	-0.19%	-0.11%
Rest of Accord Members	-0.39%	-0.42%	-0.53%	-0.68%
Rest of Midwest	-0.41%	-0.26%	-0.48%	-0.38%

*** Relative to the Reference Case**

Hybrid: Summary Results Discussion

- Using the hybrid approach to recycle allowance revenues produces the best results for Minnesota
  - Employment and output (GRP) impacts could range between -0.2% to less than -0.4% annually between 2020 and 2030 for the entire state.
  - Thus, costs in terms of job losses decrease by 50% - 70% from the worst case scenario (i.e., no revenue recycling).
  - Both regions modeled are unequivocally better off than under any of the other revenue recycling options, both in terms of employment and output.
- Under the simplifying modeling assumptions used here, using the allowance revenues to provide relief to multiple sectors affected by the Accord (consumers, businesses, etc.) seems to lead to the best possible outcome for the state, consistent with the commonly held notion that devising an appropriate allocation of allowance revenues would be important in reducing the impacts of GHG mitigation policies.

Comparing Results Across Different Revenue Recycling Options

Percentage Change in Employment and GRP for Minnesota

- The table below summarizes the incremental impacts from the Reference Case for the different revenue recycling options.
- Differences among the various revenue recycling options (except the hybrid option) are fairly small but are helpful in determining the relative impacts across options.

	Employment*		GRP*	
	2020	**2030**	**2020**	**2030**
No Revenue Recycling	-0.70%	-1.01%	-0.84%	-1.32%
Per Capita Rebates	-0.51%	-0.66%	-0.69%	-1.01%
Consumer Incentives	-0.49%	-0.64%	-0.64%	-0.91%
Business Incentives	-0.48%	-0.65%	-0.66%	-1.00%
Public Infrastructure	-0.45%	-0.56%	-0.67%	-1.00%
Worker Retraining	-0.41%	-0.54%	-0.42%	-0.69%
Hybrid Option	-0.34%	-0.29%	-0.27%	-0.35%

***Relative to Reference Case**

GRP – Average Annual Growth Rate

- Average annual growth rates for Minnesota between 2010-2020 and 2010-2030 are shown in the table, for the Reference Case and two representative revenue recycling cases.
- Under the Reference Case, the state economy is projected to grow at about 3.43% annually between 2010 and 2020 and about 3.16% annually between 2010 and 2030.

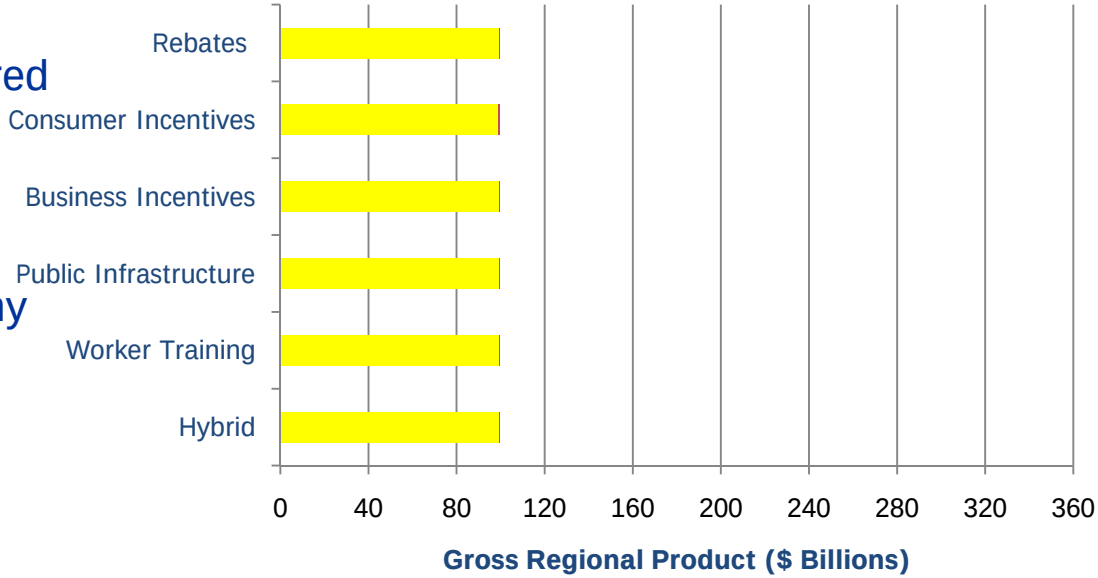
	2020	2030
Reference	3.43%	3.16%
"Worst" Scenario – Rebates	3.35%	3.11%
"Best" Scenario – Hybrid	3.40%	3.14%

For Reference, the Minnesota Average GRP growth rate for 1997-2003 was 3.3%

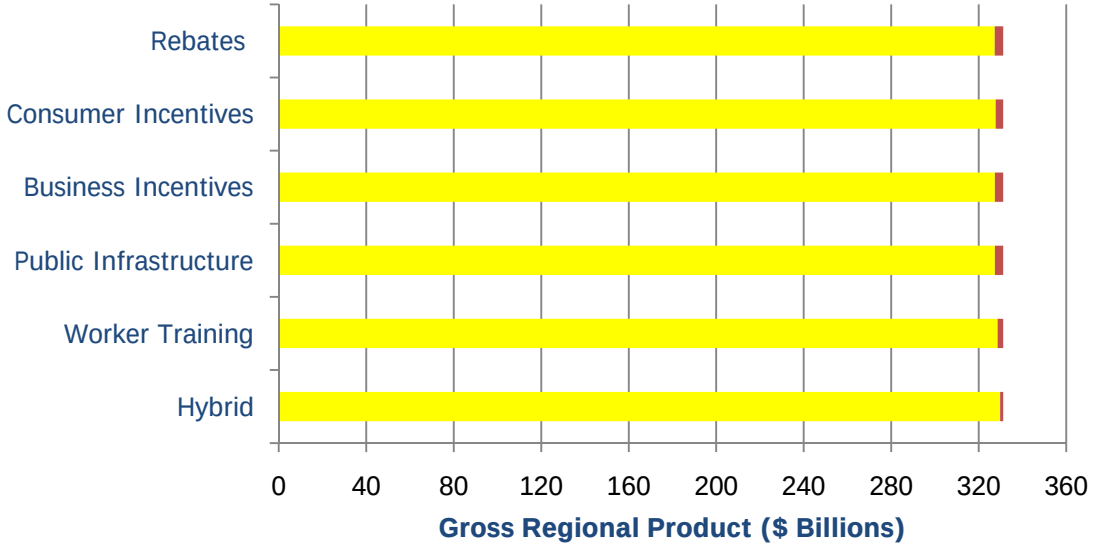
- Corresponding annual growth rates, even under the lowest impact scenario is 3.35% and 3.11%, respectively (lowest impact means the least effective revenue recycling scenario, which is the per capita rebate option. Similarly, the "best" scenario in the table shows results for the most effective revenue recycling scenario, which is the hybrid option).
- Hence the state is expected to have a robust GRP growth rate, even with the Accord in place.

Gross Regional Product Forecasts for 2030

- GRP losses for the individual revenue recycling options (the red tips in each bar) are fairly small across the options, for both regions.*
- Twin Cities has a larger economy than the rest of MN, but show similar losses proportionately.



Rest of MN

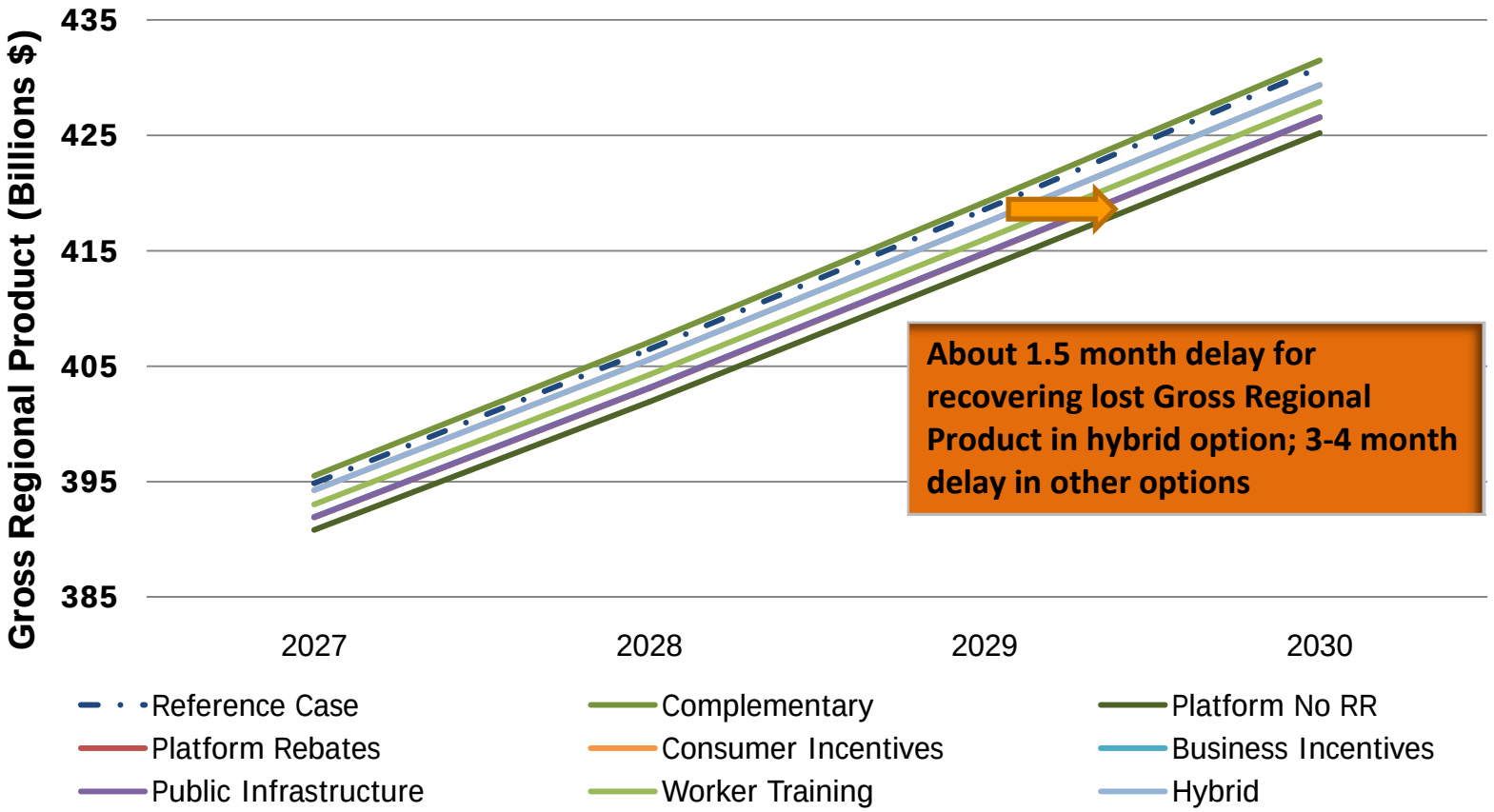


Twin Cities MSA

*The entire bar shows estimated GRP under the Reference Case, with the red tips representing the cost of climate policy under a particular revenue recycling option.

Recovery Time

- Under our modeling assumptions, the state economy could face a maximum 3-4 month delay in recovering the lost GRP (i.e., GRP under the Reference Case). This delay could be about 1-2 months under the hybrid option.



Comparing Across Revenue Recycling Scenarios

% Improvement over Per Capita Rebates, 2020		
	Employment	**GRP**
Consumer Incentives	4%	7%
Business Incentives	6%	4%
Public Infrastructure	12%	3%
Worker Retraining	20%	39%
Hybrid Option	33%	61%

% Improvement over Per Capita Rebates , 2030		
	Employment	**GRP**
Consumer Incentives	3%	10%
Business Incentives	2%	1%
Public Infrastructure	15%	1%
Worker Retraining	18%	32%
Hybrid Option	56%	65%

- Even though the actual impacts across the various revenue options are not very different, they do provide insights on how they compare against each other and their relative effectiveness in mitigating impacts.
- The tables present the percentage changes in employment and GRP impacts for each option, using the per capita rebate as the reference point.
- Results for the per capita rebate, consumer and business incentives options are fairly comparable, with differences less than 10% (both for employment and GRP).
- Thus, for the entire state, these three options may produce overall similar impacts, though they may benefit one group at the cost of another (i.e., lead to transfers across groups).

Comparing Across Revenue Recycling Scenarios, cont.

% Improvement over Per Capita Rebates, 2020		
	Employment	**GRP**
Consumer Incentives	4%	7%
Business Incentives	6%	4%
Public Infrastructure	12%	3%
Worker Retraining	20%	39%
Hybrid Option	33%	61%

% Improvement over Per Capita Rebates , 2030		
	Employment	**GRP**
Consumer Incentives	3%	10%
Business Incentives	2%	1%
Public Infrastructure	15%	1%
Worker Retraining	18%	32%
Hybrid Option	56%	65%

- The public infrastructure option provides slightly better results for employment as it supports more jobs in building/maintaining infrastructure.
- The worker retraining option could be 20% - 40% better than just using rebates. Changes in economic output (GRP) look better than employment, because of the higher skill levels of the retrained workers on average which increases their productivity.
- The hybrid option is the most promising in reducing the costs of the cap-and-trade program. This option could be over 60% more effective than the per capita rebate option. Using the no revenue recycling option as the reference point, this option could be close to 75% more effective in reducing the costs of the Accord on Minnesota residents.

Employment

Number of Jobs Created since 2010 (in Thousands)		
	2020	**2030**
Reference Case	320	651
Complementary Policies	311	660
No Revenue Recycling	291	607
Per Capita Rebates	298	622
Consumer Incentives	298	622
Business Incentives	299	622
Public Infrastructures	300	626
Worker Training	302	627
Hybrid Option	305	637

Employment

- The table on the previous page shows the incremental jobs created in Minnesota under the different scenarios, including the Reference Case and various revenue recycling options
  - The state is estimated to create about 320,000 jobs between 2010 and 2020 and over 650,000 jobs in the two decades between 2010 and 2030.
  - While the Complementary policies lead to 9,000 less jobs by 2020, it is estimated to create 9,000 additional jobs by 2030 compared to the Reference Case. This trend is consistent with the discussions above on the beneficial aspects of the Complementary policies in the long run.
  - Total number of jobs created in the state under the various revenue recycling options are fairly comparable (except the hybrid option), and could range from 14,000 fewer jobs created (under the hybrid option) to about 30,000 fewer jobs created (under the per capita rebates option) in the two decades between 2010 and 2030.

Employment – Cost-Per-Job Supported

- The following table summarizes the cost-per-job-supported for different revenue recycling options, estimated using the allowance revenues recycled annually divided by the incremental jobs created/supported for that option (relative to the no revenue recycling option).
- Resources required for supporting employment varied from about $50,000 per job (under the hybrid option) to less than $100,000 per job (for the per capita rebates option). These estimates were directly proportional to the number of jobs supported by each revenue recycling option (shown in the previous table).

Cost-Per-Job Supported (Thousand $)		
	2020	**2030**
Per Capita Rebates	87	93
Consumer Incentives	80	87
Business Incentives	76	91
Public Infrastructures	67	72
Worker Retraining	58	69
Hybrid Option	47	46

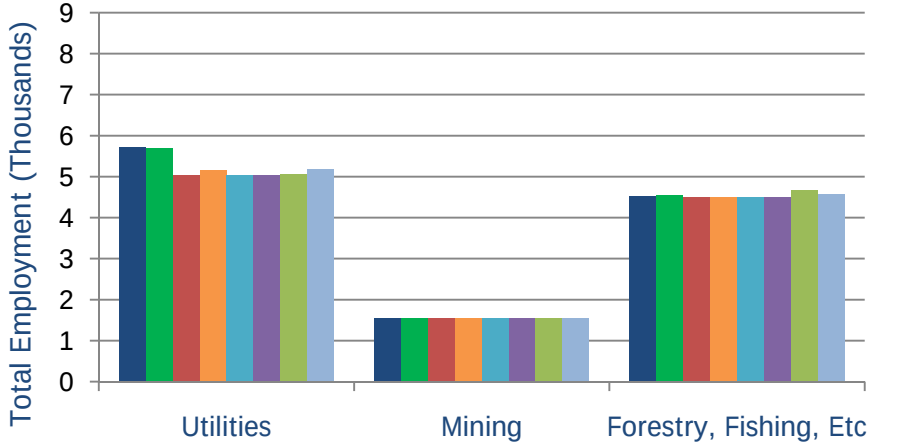
Distributional Impacts

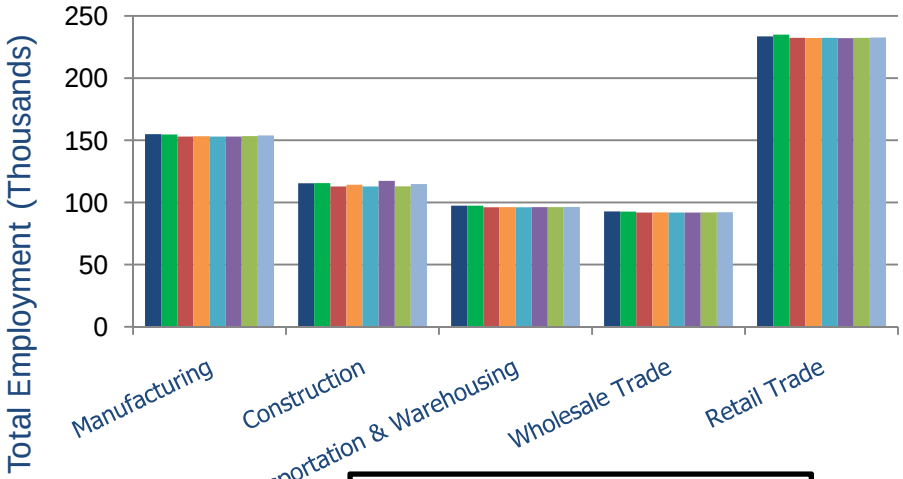
- In the next several pages, we present distributional impacts of the Midwestern Accord on different affected groups, under the various revenue recycling options
  - Impacts on different industrial sectors – results show the impact on employment levels in major industrial sectors across the two modeling regions – Twin Cities MSA and rest of Minnesota.
  - Impacts on different regions within Minnesota – results show how the Twin Cities MSA and the rest of Minnesota perform under the different scenarios.
  - Impact on consumers – results show how consumers in the two Minnesota regions are affected by the different scenarios, using metrics that compare household consumption loss as a share of their median income.

Sector Employment Levels, 2030

Reference Case | Comp. Policy | Rebates | Consumer Incentives
Bus Incentives | Pub Infrastructure | Worker Training | Hybrid

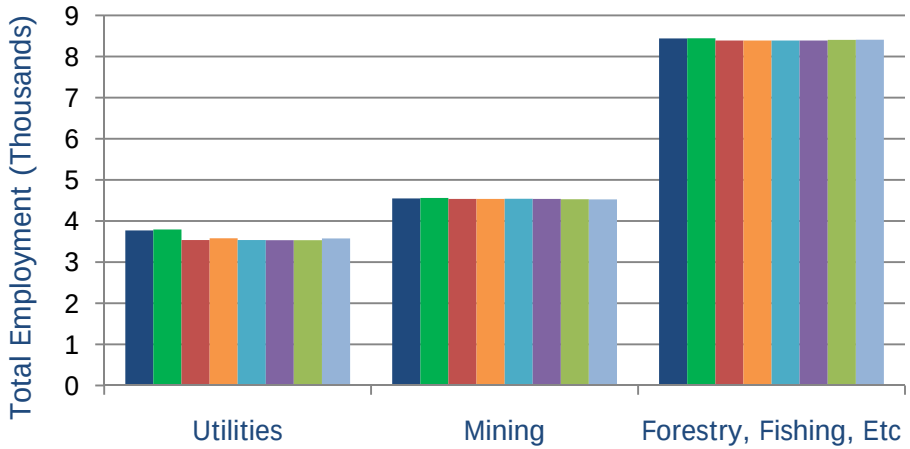
Twin Cities MSA





Not Shown: Service Sector- Approx 1,750,000 Jobs

Rest of MN

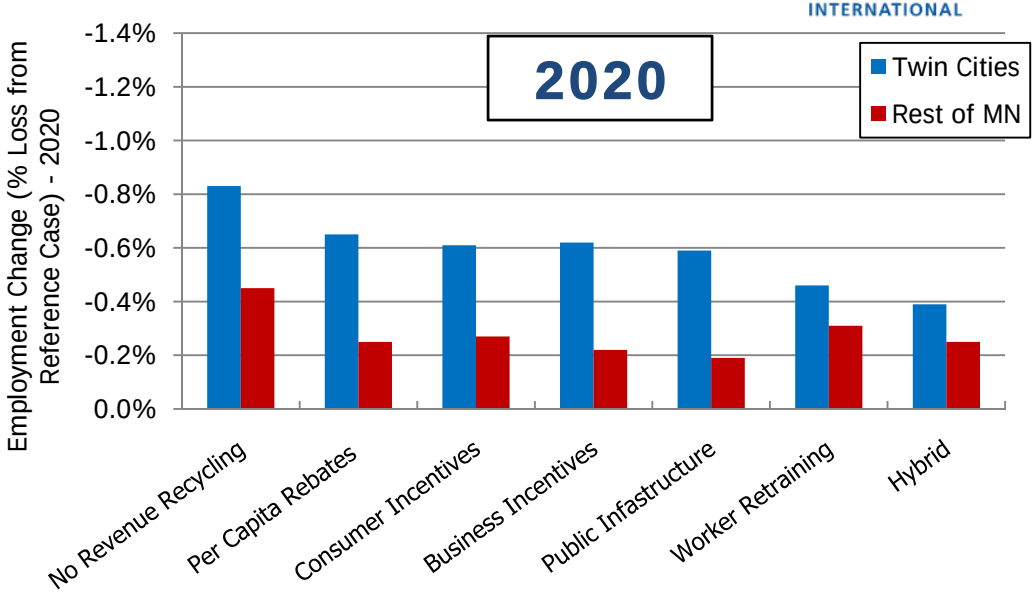


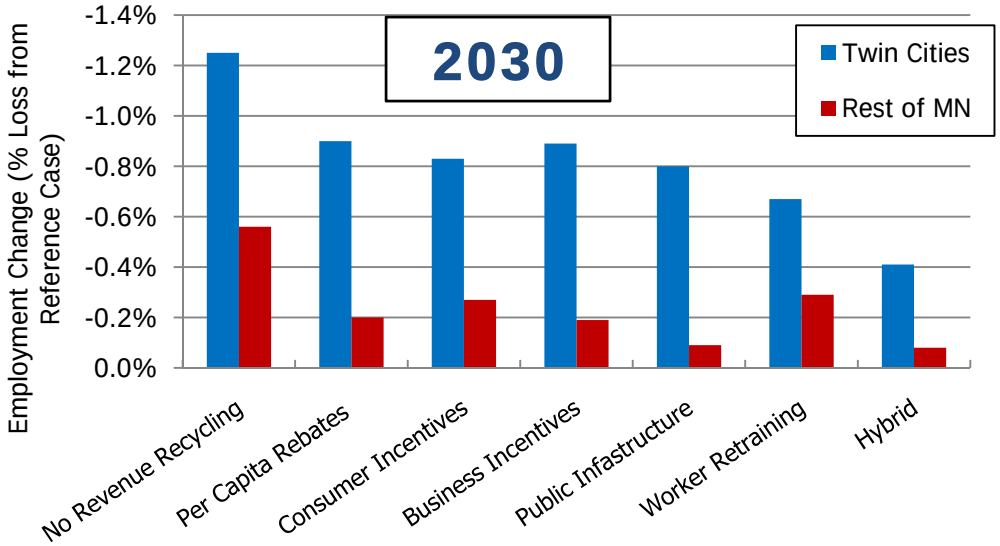
Not Shown: Service Sector- Approx 750,000 Jobs

Sector Employment Levels

- The utility sector has the most significant job losses relative to the Reference Case in both regions, with slightly larger losses in Twin Cities than rest of Minnesota. This is likely because of the assumption that most of the incremental cleaner generation will be located in the rest of Minnesota region
  - While results for the utility sector are comparable across the different revenue recycling options, the consumer incentives and hybrid options seem to mitigate job losses marginally.
- Job losses for the mining and agriculture-related sectors do not appear to be significant.
- The manufacturing sector shows some job losses across the options, relative to the Reference Case.
- The construction sector could actually gain jobs under the public infrastructure and hybrid options, due to the significant investments in highway and mass transit requirements for the state.

Regional Employment Impacts





Regional Employment Impacts

- Job losses for the Twin Cities MSA could range from a little above roughly -0.4% to about -0.6% in 2020, under different revenue recycling options. Corresponding losses for rest of Minnesota could be about -0.2% to about -0.3%. Losses are measured incremental over the Reference Case.
- In 2030, rest of Minnesota seem to fare better, especially under the public infrastructure option with losses at only about -0.1%. Same is true for the hybrid option. Job losses in the Twin Cities MSA are generally higher in 2030, compared to the rest of Minnesota.
- Among the various revenue recycling options, the hybrid option is beneficial to both regions in Minnesota as it produces the least number of job losses. Losses could be about -0.4% for Twin Cities MSA for both 2020 and 2030. For rest of Minnesota, slightly above -0.2% in 2020 to about -0.1% in 2030, under our modeling assumptions.
- Given the uncertainties in various modeling assumptions, losses of magnitude this small could well be in the noise level.
- Similar patterns, though slightly different magnitudes, are also true for the GRP losses across the two regions for the different revenue recycling options.

Consumer Impacts: Consumption Loss as a Share of Income

- A common measure of household impacts for these types of policies is loss to household consumption. Consumption measures how real disposable income is spent by households on their representative basket of goods.
- Using the ratio of lost consumption as a share of median income can illustrate how a policy is likely to impact people's pocketbooks across the modeling regions and under various revenue recycling options.
- Given the significant differences in median income between the urban Twin Cities MSA and the mostly semi metro/rural rest of Minnesota, the ratio of consumption losses as a share of median income are likely to vary significantly between the regions
  - Using US Census-based historical median income data (for 2000) and an estimated average growth rate of REMI's per capita income, we estimated that median income in Twin Cities is likely to be about $103,800, and in rest of Minnesota to be about $66,800 in 2030 (in 2000$).

Consumer Impacts: Consumption Loss as a Share of Income, 2030

- Under all the revenue recycling options, percentage loss in consumption (relative to the Reference Case) is always less than 2% of median income, in 2030. Highest consumption loss is about 1.5% in Twin Cities MSA under the public infrastructure option.

- Consumption loss percentages are generally higher in Twin Cities compared to rest of Minnesota. This is likely because rest of Minnesota benefits more from higher investments in cleaner generation and prices tend to go up more in urban areas than in semi urban/rural areas.

- Consumption losses in rest of Minnesota under the rebate and business incentives options are close to zero, likely due to the large amounts of lump sum rebate checks given out to all residents in these options, in conjunction with generally lower price increases.

Additional Runs Conducted: Cap-and-Trade Only Case – Summary Findings

- In addition to the various revenue recycling options for the Platform Case discussed above, we also analyzed similar options for the Cap-and-Trade Only Case. Detailed discussion of those results are presented in Appendix B below, here we discuss some summary findings.
  - Similar to the trends for the Platform Case, differences among the various revenue recycling options (except the hybrid option) are fairly small, especially in the long run (2030), but are helpful in determining the relative impacts across options.
  - Without any revenue recycling (i.e. no revenue recycling option), impacts under the Cap-and-Trade Only run are consistently higher for all years than those under the Platform Case. This is expected since the Cap-and-Trade Only run excludes the Complementary policies that helped keep the cost of the program down under the Platform Case.
  - Results for most of the revenue recycling options are slightly better with the Cap-and-Trade Only runs when compared to the corresponding Platform Case runs, especially in the early years (i.e., by 2020). This is mainly due to the substantially higher allowance revenue amounts available under the Cap-and-Trade Only Case (because of much higher allowance prices). The positive effects of these higher revenue amounts outweigh the negative effects of the lack of Complementary policies for these runs. In the long run, however, the absence of the Complementary polices for the Cap-and-Trade Only Case seem to have a bigger effect, especially on Gross Regional Product, leading to results that are slightly worse than those for the Platform Case revenue recycling options. (See slide 149 in Appendix B for more details).

Health Benefits Impacts

Task Overview

- The goal of this part of the study was to estimate the “indirect” public health benefits of the Midwestern Accord for the residents of Minnesota.
- Benefits are estimated for three alternative GHG policy scenarios with respect to the Reference Case (REF in graphics of this section)
  - Complementary Policy Case (Graphics in this section refer to this run as CPC).
  - Platform Case with FJD (Graphics in this section refer to this run as FJD).
  - Cap-and-Trade Only Case or ‘Pure Cap-and-Trade’ (Graphics in this section refer to this run as PCT).
- Benefits are estimated for two target years: 2015 and 2025.
- Benefits are calculated for the Twin Cities region and the rest of the Minnesota separately.

Air Quality Modeling Methodology

- Emissions from Electric Generating Utility (EGU) sources are estimated from IPM
  - Hourly emissions for each EGU stack in the Minnesota and neighboring states are estimated based on IPM output.
  - NO_x, SO_2 and $PM_{2.5}$ emissions are modeled.
  - It is assumed that 90% of NO_x emissions is emitted as NO and the rest as NO_2.
  - Stacks with similar stack parameters at the same location are combined into a single stack for computational efficiency.
  - A total of eight emissions files are generated – four scenarios for the two analysis years.

Air Quality Modeling Methodology

- Ambient concentrations are modeled using CALPUFF
  - CALPUFF is an EPA-approved air quality model for long range transport.
  - Modeling domain encompasses North Dakota, Minnesota, Iowa and parts of South Dakota and Wisconsin. This large modeling domain can capture impacts from any displacement of emissions from Minnesota to neighboring states because of climate policies.
  - Meteorological fields are obtained from NCAR's fifth-generation mesoscale Meteorological Model (MM5) simulations at 12 X 12 km resolution. (Meteorological fields are gridded data of wind speeds, humidity, mixing height, vertical turbulence parameters etc.)
  - MM5 meteorological data was processed using CALMET to prepare inputs for CALPUFF.
  - Dispersion coefficients are calculated from micrometeorological variables present in MM5 input dataset.
  - Secondary PM formation from SO_2 and NO_x are modeled using RIVAD chemical mechanism of CALPUFF.

Air Quality Modeling Methodology

- Ambient concentrations are modeled using CALPUFF
  - Modeling grid is 12 X 12 km in horizontal dimension. There are 12 vertical layers at the following heights above the ground level:
    20, 40, 80, 160, 300, 600, 1000, 1500, 2200, 3000, 4000, and 5000m.
  - Receptor points are placed at the centroid of each census tract to achieve high resolution ambient concentration fields in the densely populated Twin Cities MSA counties.
  - For the counties outside the Twin Cities region, receptors are placed at county centroids.
  - All EGU stacks are modeled as point sources.
  - Wet or dry deposition is modeled only for gas-phase species.
  - Hourly background ozone concentrations are obtained for measurements at air quality monitors in Minnesota.
  - A default ammonia background concentration of 10 ppb is assumed. This value is based on the Interagency Workgroup on Air Quality Modeling (IWAQM) recommendations for modeling long-range transport. This report prescribes a value of 10 ppb for ammonia background concentration for grasslands when monitoring data is not available.
  - One year of hourly emissions and meteorology are simulated.

Health Benefit Determination

- Health benefits are determined using EPA's BenMAP model
  - BenMAP = Benefit Mapping and Analysis Program
  - EPA's publicly available latest version (3.0) of BenMAP is used in this study to measure
    - —Mortality impacts
    - —Morbidity (non-fatal health effects) impacts
      - Loss of work days, respiratory hospital admissions, and emergency room visits
  - Concentration-Response (C-R) functions are chosen based on EPA's default set-up.
  - Use embedded cost-benefit functions to determine health impact costs.

Emissions Summary

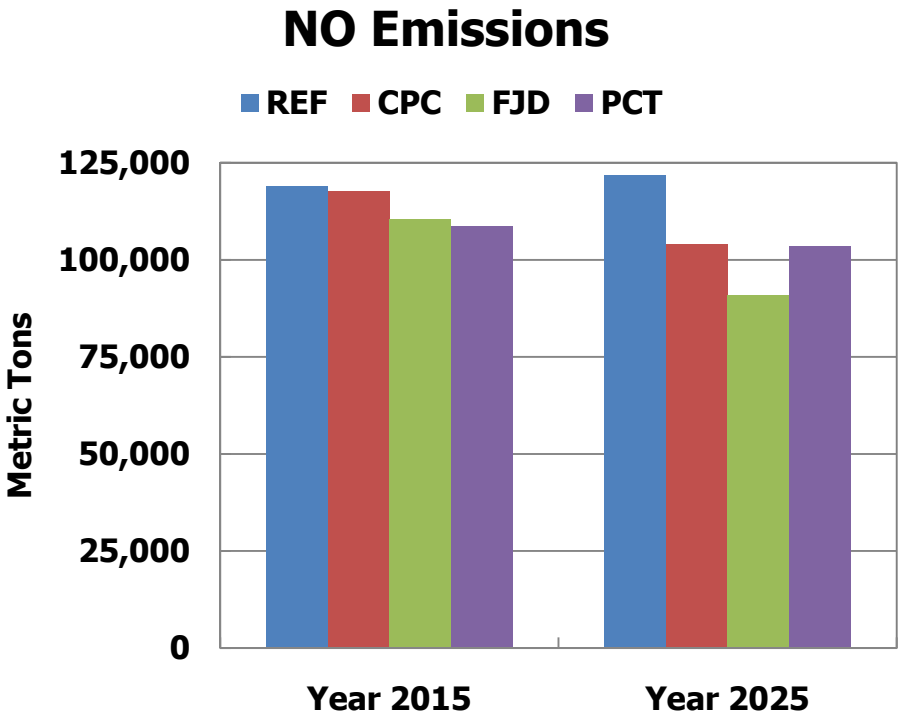
Emission changes

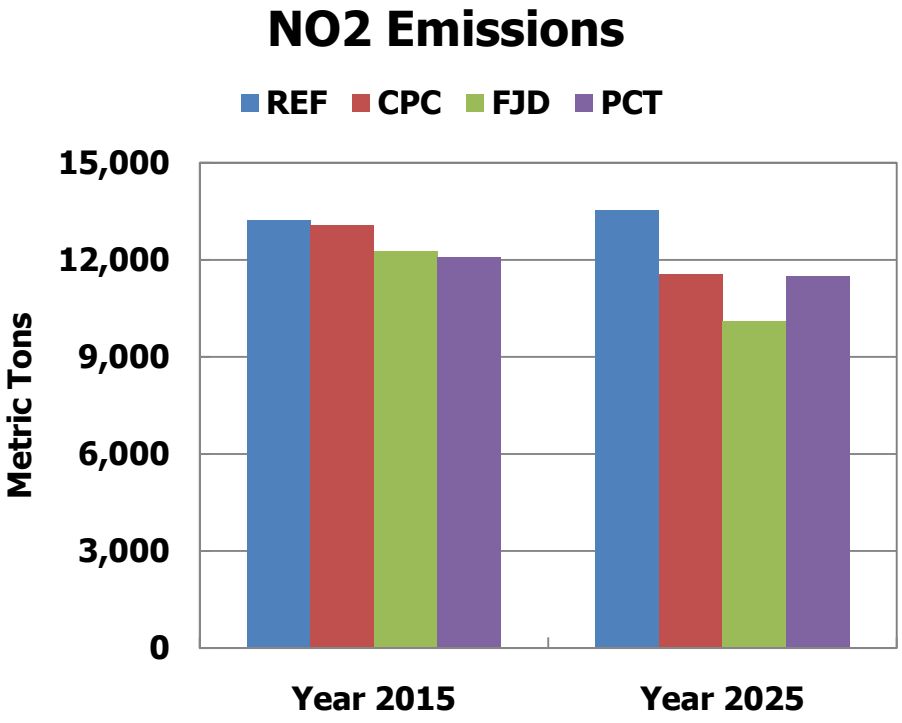
- Next three slides show emission changes predicted for each of the policy scenarios.
- Emission changes are relatively small (<10%) for all three GHG alternative policy scenarios in 2015.
- For 2015, the Complementary Policy Case results in very modest changes (~ 1%).
- For 2015, the Cap-and-Trade Only Case results in highest reduction of emissions.
- By 2025, there is a 15%-30% decrease depending on the alternatives.
- For 2025, the Platform Case results in highest reduction of emissions followed by the Cap-and-Trade Only and Complementary Policy Cases, respectively.
- Reductions are similar for each SO_2, NO, NO_2 and PM in respective scenarios.
- All emission species show decrease in emissions by 2025.

Emissions Summary

Year	Species	CPC Tons/y	%(CPC-REF)	FJD Tons/y	%(FJD-REF)	PCT Tons/y	%(PCT-REF)	REF Tons/y
2015	NO	117,592	-1.15%	110,402	-7.19%	108,625	-8.69%	118,959
	NO2	13,066	-1.15%	12,267	-7.19%	12,069	-8.69%	13,218
	PM2.5	20,051	+0.39%	18,621	-6.77%	18,096	-9.40%	19,973
	SO2	218,789	+0.09%	220,998	+1.10%	197,708	-9.55%	218,593
2025	NO	103,874	-14.76%	90,930	-25.38%	103,379	-15.17%	121,863
	NO2	11,542	-14.76%	10,103	-25.38%	11,487	-15.17%	13,540
	PM2.5	17,512	-14.30%	15,178	-25.72%	17,422	-14.74%	20,434
	SO2	189,271	-17.93%	160,403	-30.45%	179,232	-22.28%	230,622

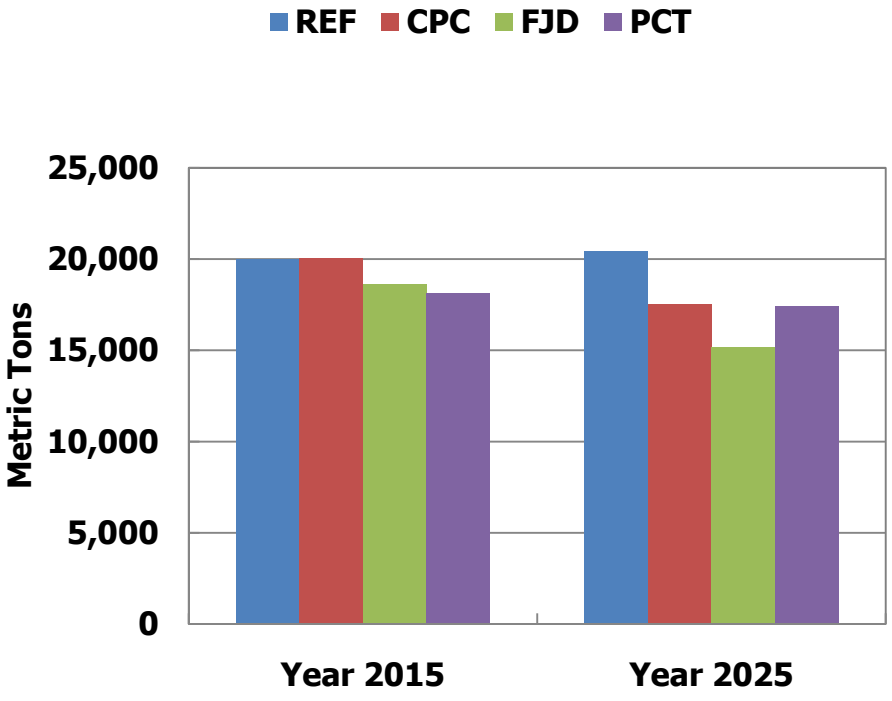
Emissions Summary



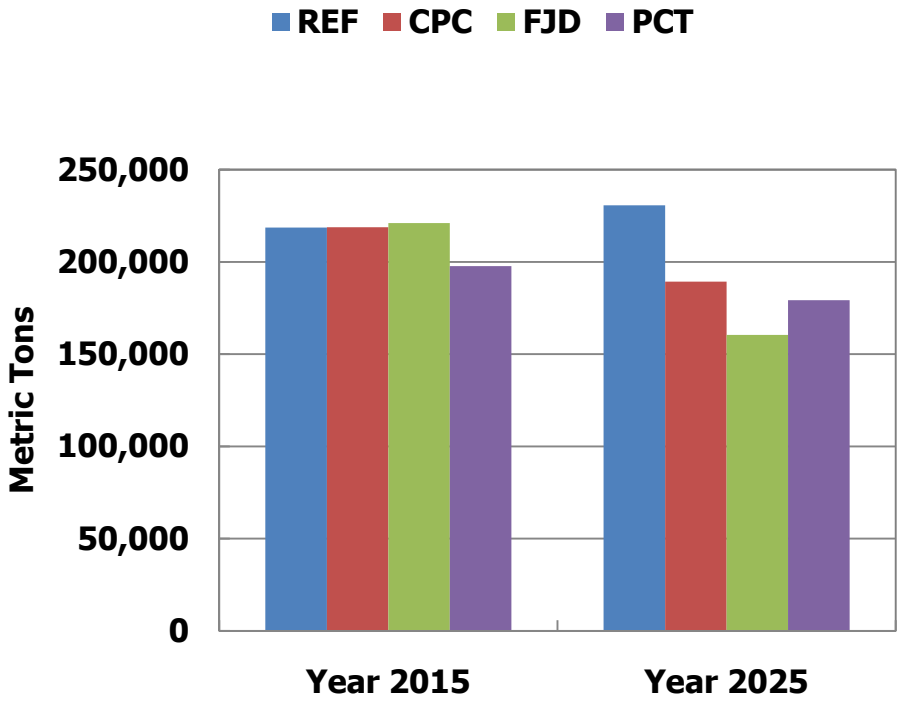


Emissions Summary

PM2.5 Emissions



SO2 Emissions

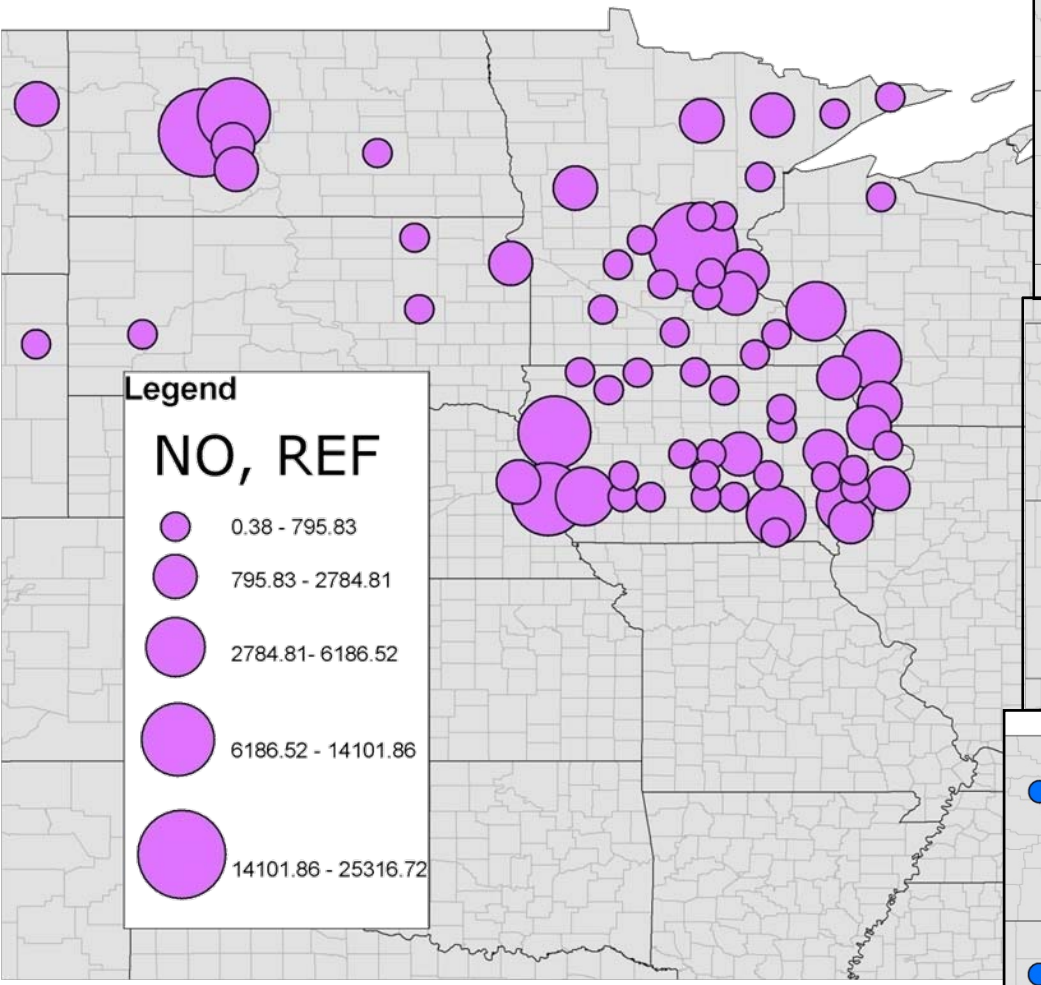


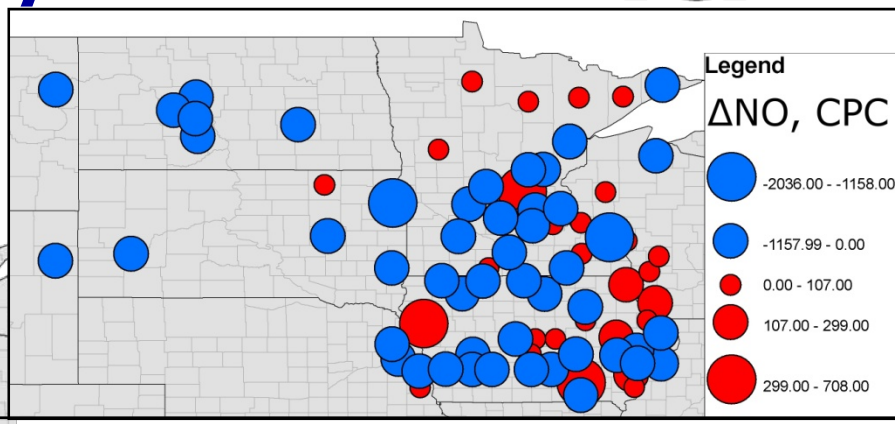
Emissions Summary

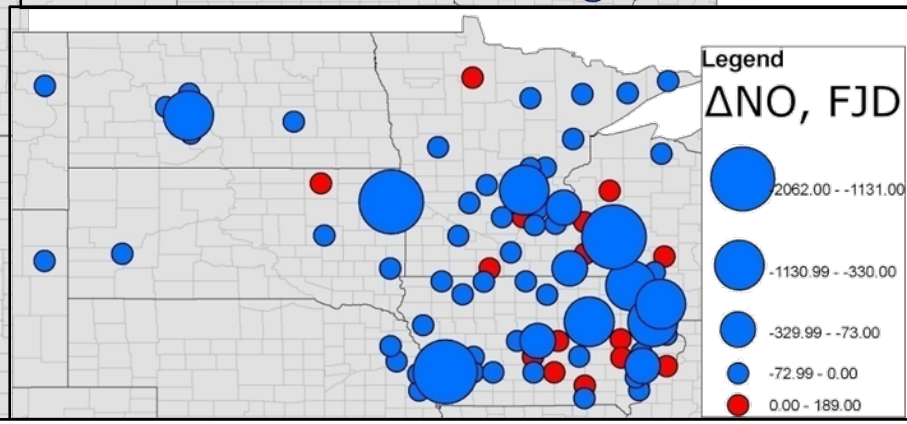
- Geographic distribution of EGU emissions
  - The next two slides show how EGU emissions vary geographically in the modeling domain.
  - Figures on the left show county-wide aggregated emissions for the Reference Case.
  - Figures on the right show change in county-wide aggregated emissions for the three policy scenarios (blue circles show decrease in emissions with respect to the Reference Case and red circles show increases).
  - Within Minnesota most emissions from EGU sources occur in the Twin Cities region.
  - Most EGU non-Minnesota emissions that potentially impact ambient air quality in Minnesota occur in Iowa, followed by the sources in North Dakota.

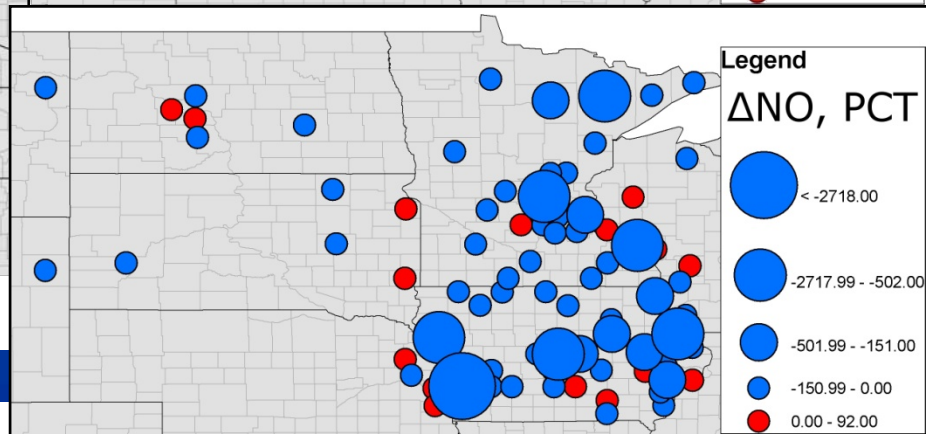
2015 NO Emissions by County

(metric tons)



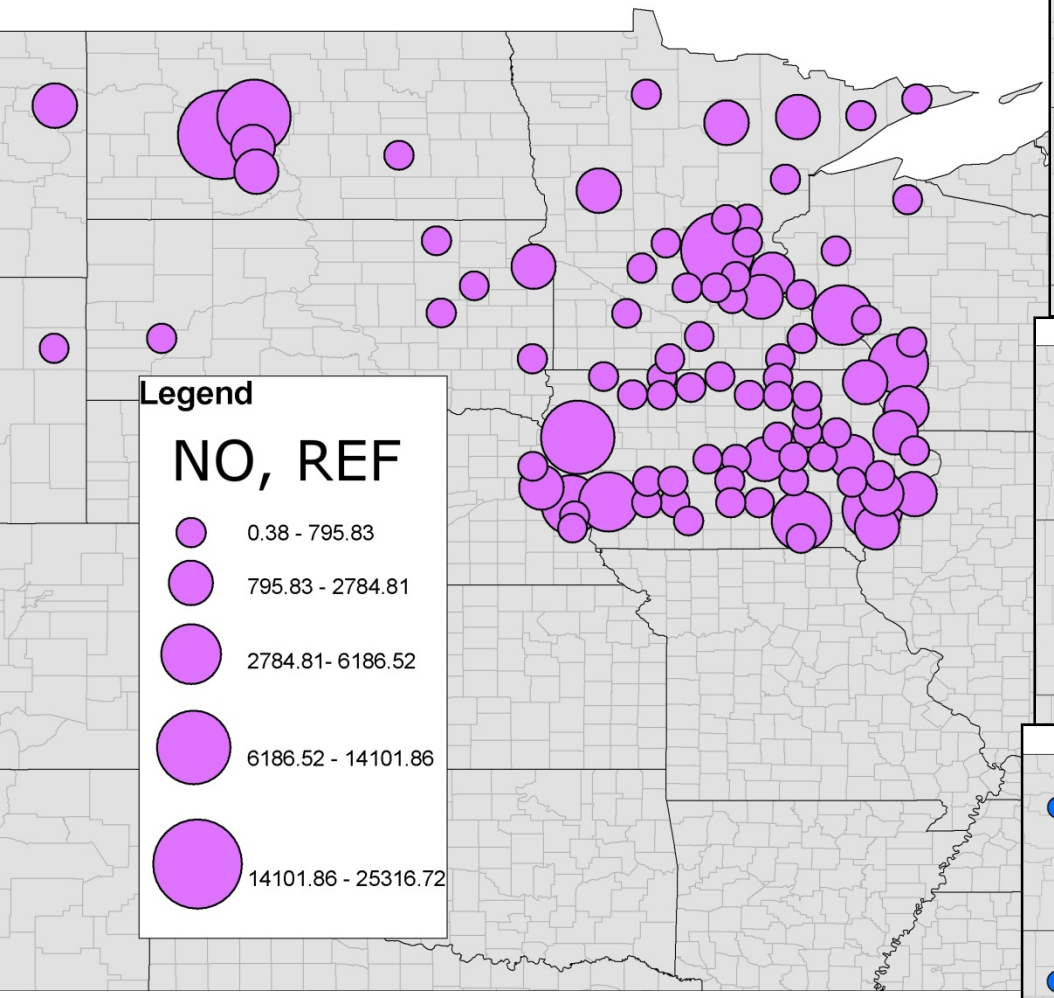


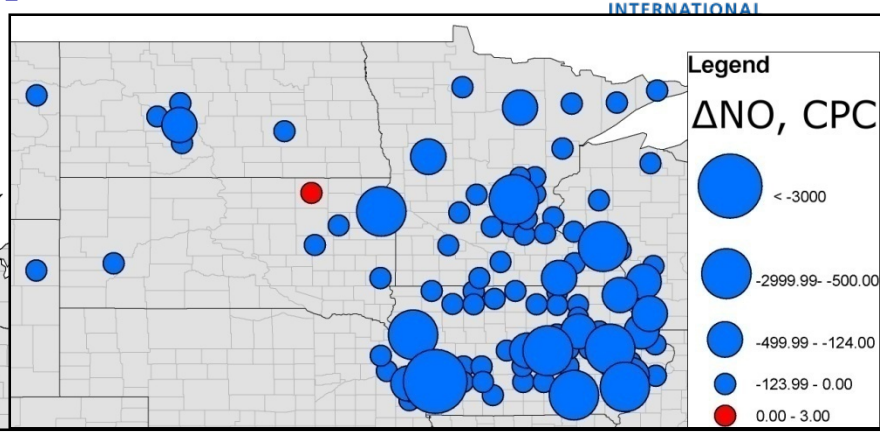


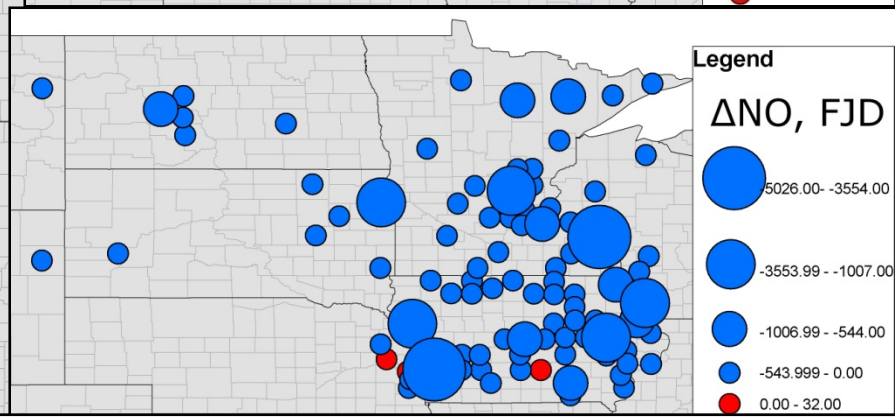


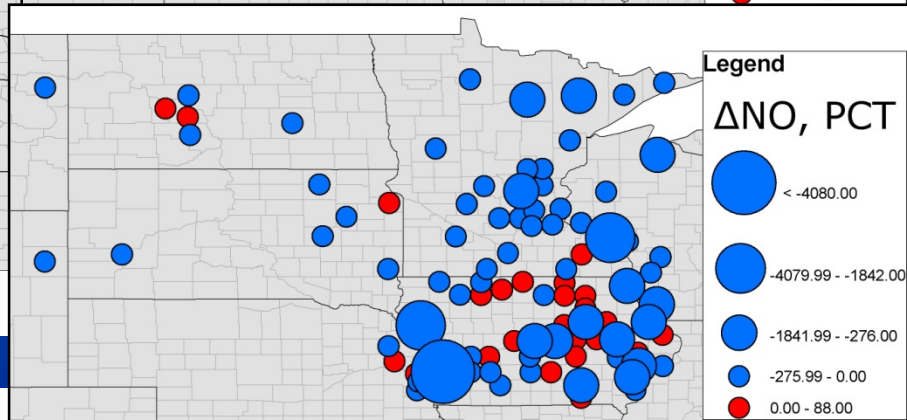
2025 NO Emissions by County

(metric tons)









Emissions Summary

- Geographic distribution of EGU emissions
  - For 2015 scenarios, emission reductions are more uniform for the Complementary Policy Case compared to the Platform and Cap-and-Trade Only Cases.
  - For 2015, Platform and Cap-and-Trade Only Cases show relatively large reductions at fewer locations when compared with the Complementary Policy Case.
  - For 2015, EGU emission changes for policy scenarios are mixed where both increases and reductions are predicted.
  - For 2015, emissions reductions are relatively large for Complementary Policy Case when compared with the Platform and the Cap-and-Trade Only Cases.
  - For 2025, emissions reductions are predicted for Complementary Policy and Platform Cases in most of the counties.
  - For 2025, Cap-and-Trade Only Case shows more mixed changes in emissions where both increases and reductions are predicted.

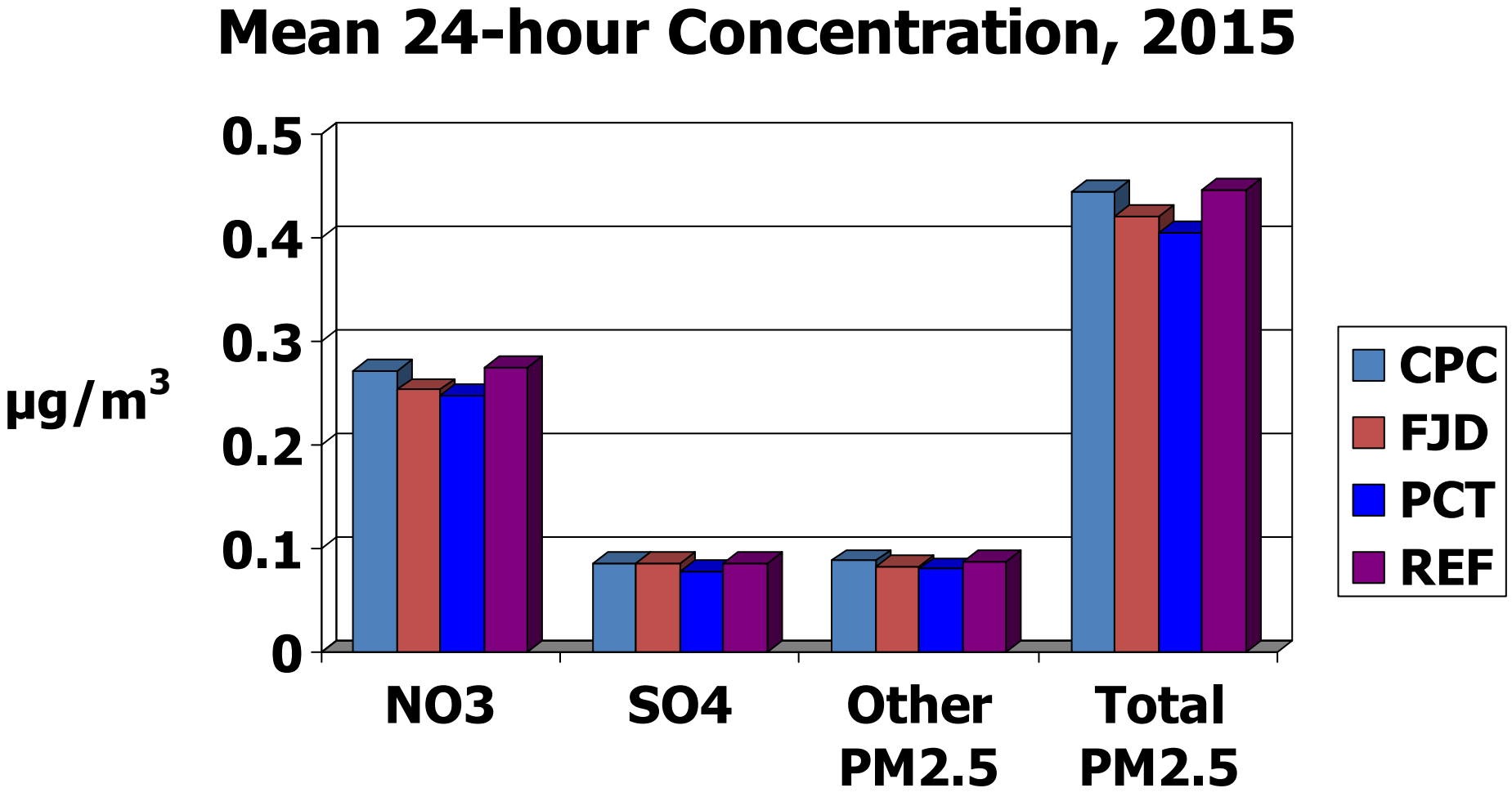
Concentrations Summary

- Region-wide average concentration changes
  - Change in ambient concentrations reflect the change in emissions for each of the policy scenarios and analysis years.
  - Total $PM_{2.5}$ is dominated by nitrate (NO_3).
  - Correspondingly, the largest concentration changes are for nitrates.
  - 2015 average concentration changes are small at less than 10%.
  - 2025 average concentration changes are larger with decrease in concentration of ~30% sulfate (SO_4) for the Platform Case.

Concentrations Summary

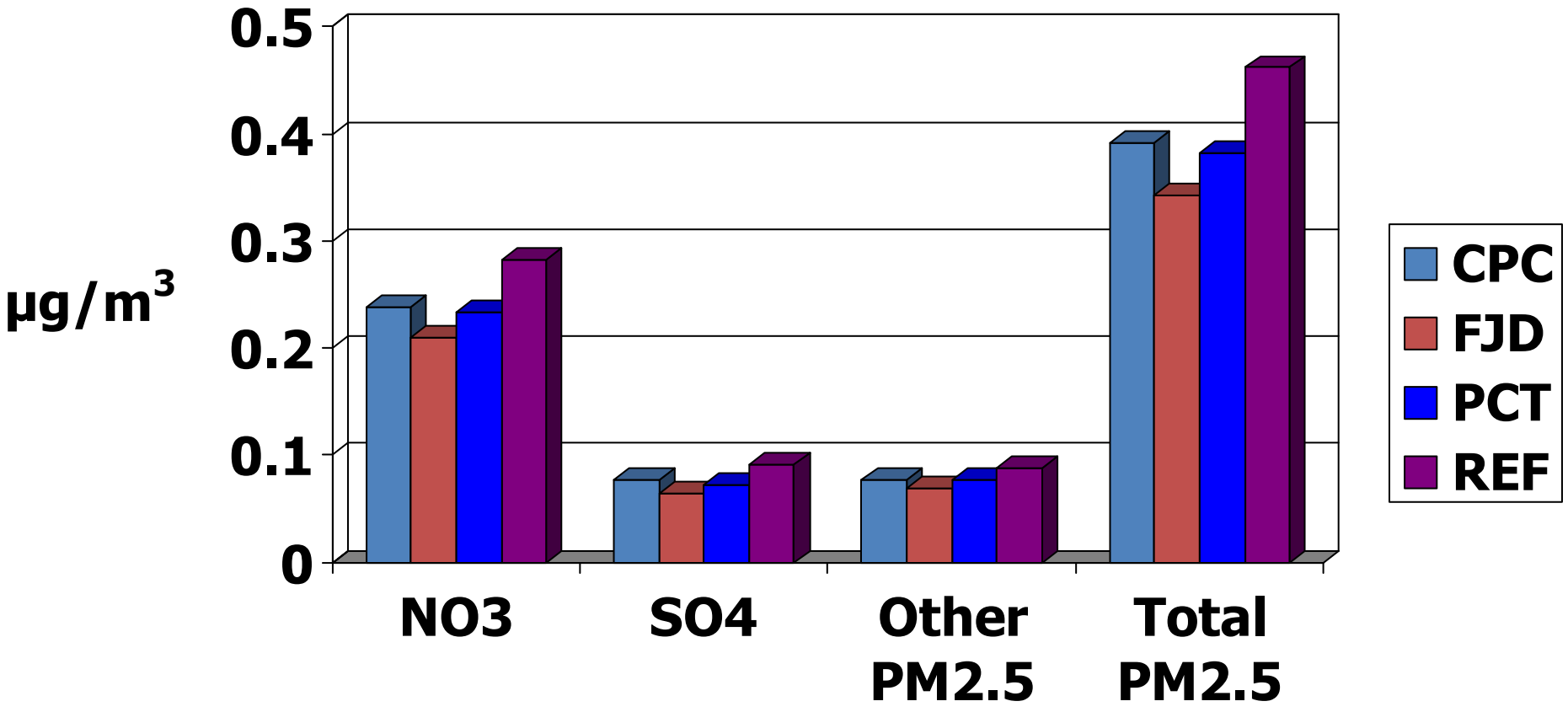
Year	Species	CPC µg/m^3	%(CPC-REF)	FJD µg/m^3	%(FJD-REF)	PCT µg/m^3	%(PCT-REF)	REF
2015	NO3	0.27	-1.04%	0.25	-7.82%	0.25	-9.99%	0.27
	Primary PM2.5	0.09	0.62%	0.08	-5.94%	0.08	-8.54%	0.09
	SO4	0.08	-0.56%	0.09	0.12%	0.08	-8.81%	0.09
	Total PM2.5	0.44	-0.63%	0.42	-5.94%	0.40	-9.48%	0.45
2025	NO3	0.24	-15.91%	0.21	-26.08%	0.23	-17.51%	0.28
	Primary PM2.5	0.08	-12.44%	0.07	-21.68%	0.08	-13.35%	0.09
	SO4	0.08	-15.95%	0.06	-29.67%	0.07	-21.07%	0.09
	Total PM2.5	0.39	-15.26%	0.34	-25.95%	0.38	-17.42%	0.46

Concentrations Summary



Concentrations Summary

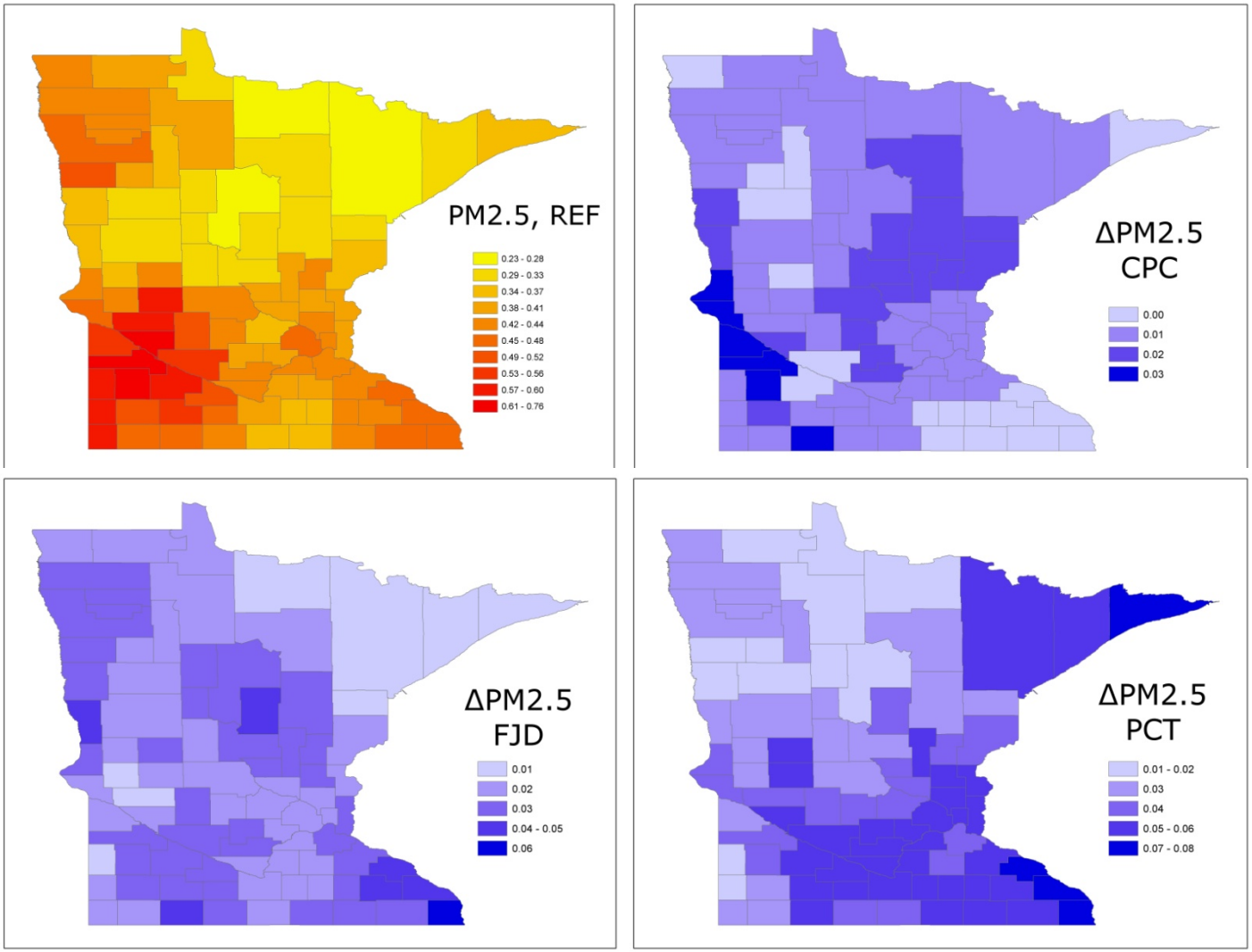
Mean 24-hour Concentration, 2025



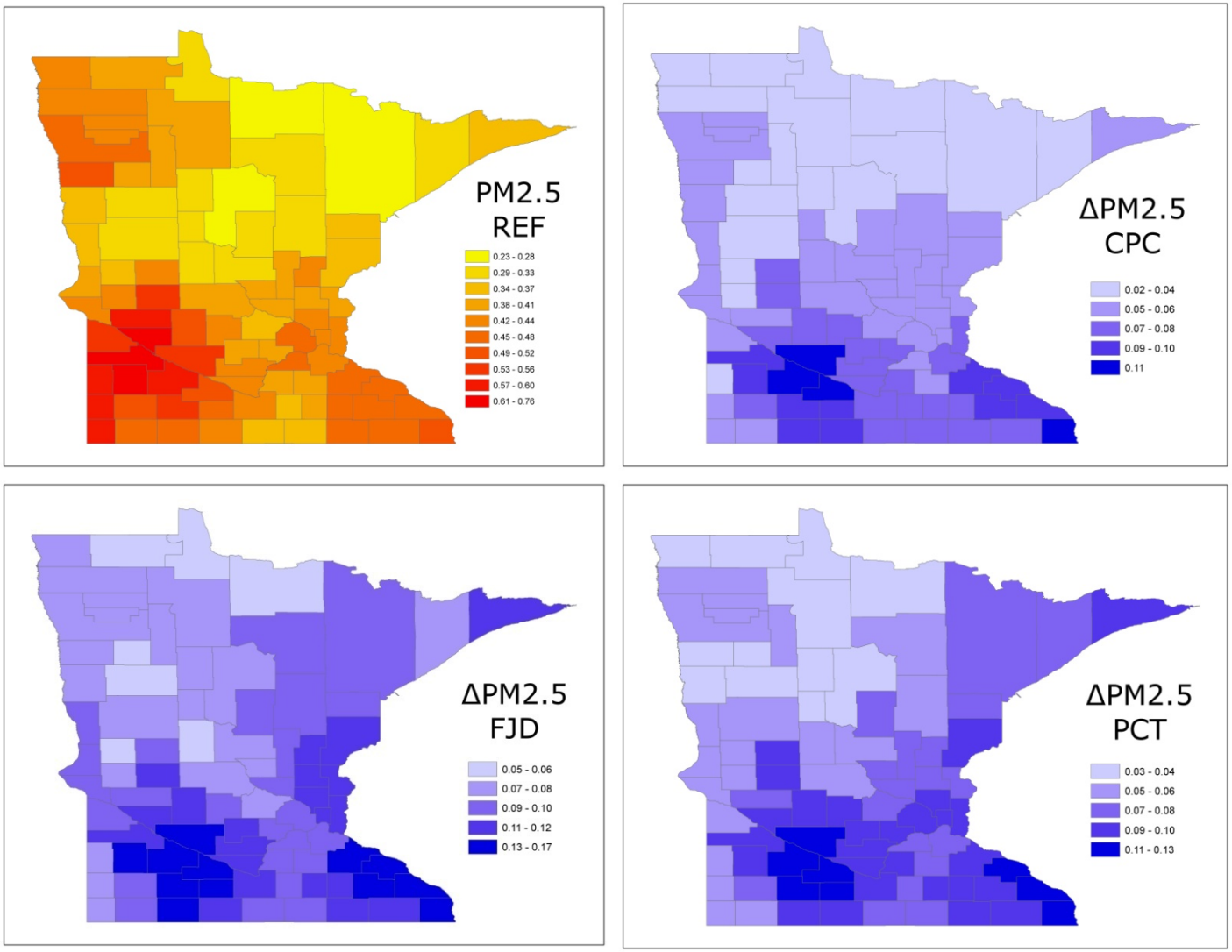
Spatial Distribution of Concentration Impacts

- The next two slides illustrate the spatial distribution of concentration impacts
  - Red and yellow show areas of total concentration for Reference Case.
  - Purple areas show changes relative to the Reference Case.
  - Largest concentration changes generally seen in southern half of Minnesota.
  - Platform and Cap-and-Trade Only reductions more widely spread over Minnesota.

2015 PM 2.5 Concentrations by County



2025 PM 2.5 Concentrations by County



Health Benefits Summary

- Incidences of health endpoints
  - The next two slides show the impact of the three policy scenarios on the number of incidences of health endpoints chosen for this study in 2015 and 2025.
  - "All Cause Incidences" – are the number of incidences that occur each year in a business-as-usual world which may or may not be related to air quality, but do not reflect the impacts from the Accord.
  - Health impacts are calculated separately for the Twin Cities region and the rest of Minnesota.
  - Left most column shows incidences that occur from all causes.
  - Reductions in incidences of respective health endpoints are shown for the three policy scenarios.
  - For 2015, Cap-and-Trade Only Case is predicted to provide most reductions in the incidences of all health endpoints, followed by the Platform and Complementary Policy Cases, respectively.
  - For 2025, Platform Case provides maximum benefits followed by the Cap-and-Trade Only and Complementary Policy Cases.

2015 Health Impact - Incidence

Area	Endpoint	Reference	Number of Cases Avoided			All Cause Incidences
			CPC	FJD	PCT	
Counties Outside Minneapolis-Saint Paul	Mortality	Laden et al. (2006)	3	7	12	18,701
	Work Loss Days	Ostro (1987)	104	308	495	2,498,245
	Emergency Room Visits, Respiratory	Norris et al. (1999)	1	3	4	6,015
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Ito (2003)	1	2	4	47,385
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	<1	1	2	14,960
	Asthma Exacerbation	Ostro et al. (2001)	31	94	150	2,369,295
	Chronic Bronchitis	Abbey et al. (1995)	1	2	3	4,763
Minneapolis-Saint Paul Metropolitan Area	Mortality	Laden et al. (2006)	4	7	17	23,494
	Work Loss Days	Ostro (1987)	251	494	1,114	5,058,139
	Emergency Room Visits, Respiratory	Norris et al. (1999)	2	5	11	13,668
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Ito (2003)	1	2	5	62,230
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	1	2	4	22,332
	Asthma Exacerbation	Ostro et al. (2001)	82	162	364	5,174,949
	Chronic Bronchitis	Abbey et al. (1995)	1	3	6	8,634

2025 Health Impact - Incidence

Area	Endpoint	Reference	Number of Cases Avoided			All Cause Incidences
			CPC	FJD	PCT	
Counties Outside Minneapolis-Saint Paul	Mortality	Laden et al. (2006)	17	29	22	19,929
	Work Loss Days	Ostro (1987)	695	1,113	853	2,443,201
	Emergency Room Visits, Respiratory	Norris et al. (1999)	7	11	8	6,542
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Ito (2003)	7	11	8	62,103
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	4	6	5	17,524
	Asthma Exacerbation	Ostro et al. (2001)	239	381	292	2,611,496
	Chronic Bronchitis	Abbey et al. (1995)	4	7	5	5,112
Minneapolis-Saint Paul Metropolitan Area	Mortality	Laden et al. (2006)	26	42	34	27,461
	Work Loss Days	Ostro (1987)	1,562	2,527	2,055	5,378,183
	Emergency Room Visits, Respiratory	Norris et al. (1999)	17	27	22	15,969
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Ito (2003)	10	17	13	90,816
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	6	10	8	28,393
	Asthma Exacerbation	Ostro et al. (2001)	572	926	753	6,169,348
	Chronic Bronchitis	Abbey et al. (1995)	8	14	11	9,813

Health Benefits Summary

- Valuation of health endpoints
  - The next two slides show economic benefits of the three policy scenarios derived from the avoidance of health endpoint incidences.
  - Economic benefits are calculated separately for the Twin Cities region and the rest of Minnesota.
  - Economic benefits are presented in year 2000 dollars.
  - For 2015, the Cap-and-Trade Only Case is predicted to provide the highest economic benefit from avoidance of health endpoint incidences. The value of avoided premature deaths contributes the highest to overall economic benefits.
  - For 2025, Platform Case provides the maximum benefits, followed by the Cap-and-Trade Only and Complementary Policy Cases.
  - In all cases health benefits are driven by reductions in mortality.

2015 Health Impact - Valuation

Area	Endpoint	Reference	Valuation Method	Health Cost Savings (2000$)		
				CPC	FJD	PCT
Counties Outside Minneapolis-Saint Paul	Mortality	Laden et al. (2006)	VSL $4.8M 1990$	$18,905,416	$52,540,916	$85,510,631
	Work Loss Days	Ostro (1987)	Median daily wage	$11,196	$33,650	$55,144
	Emergency Room Visits, Respiratory	Norris et al. (1999)	COI: Standford et al. (1999)	$232	$701	$1,115
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Moolgavkar (2000)	COI: med costs + wage loss	$11,168	$32,100	$51,537
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	COI: med costs + wage loss	$6,909	$19,816	$31,846
Minneapolis-Saint Paul Metropolitan Area	Mortality	Laden et al. (2006)	VSL $4.8M 1990$	$27,273,006	$54,062,597	$121,898,704
	Work Loss Days	Ostro (1987)	Median daily wage	$35,571	$70,725	$159,554
	Emergency Room Visits, Respiratory	Norris et al. (1999)	COI: Standford et al. (1999)	$634	$1,246	$2,816
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Moolgavkar (2000)	COI: med costs + wage loss	$19,103	$38,102	$85,715
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	COI: med costs + wage loss	$11,297	$22,454	$50,596

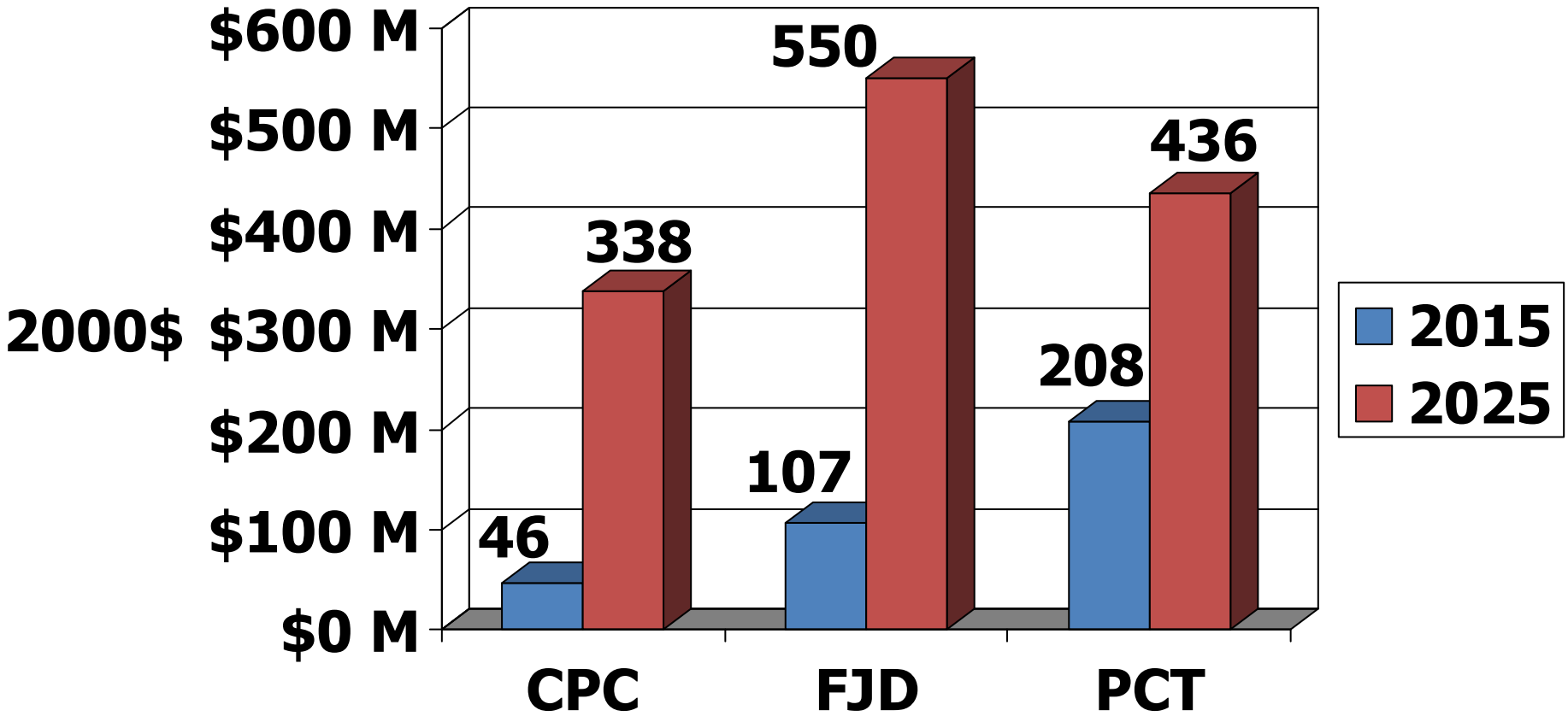
2025 Health Impact - Valuation

Area	Endpoint	Reference	Valuation Method	Health Cost Savings (2000$)		
				CPC	FJD	PCT
Counties Outside Minneapolis-Saint Paul	Mortality	Laden et al. (2006)	VSL $4.8M 1990$	$136,139,820	$223,562,207	$170,547,859
	Work Loss Days	Ostro (1987)	Median daily wage	$76,656	$123,238	$94,784
	Emergency Room Visits, Respiratory	Norris et al. (1999)	COI: Standford et al. (1999)	$1,755	$2,794	$2,139
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Moolgavkar (2000)	COI: med costs + wage loss	$88,825	$143,477	$109,650
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	COI: med costs + wage loss	$55,053	$89,050	$68,064
Minneapolis-Saint Paul Metropolitan Area	Mortality	Laden et al. (2006)	VSL $4.8M 1990$	$201,469,454	$325,704,536	$264,361,475
	Work Loss Days	Ostro (1987)	Median daily wage	$224,597	$363,416	$295,535
	Emergency Room Visits, Respiratory	Norris et al. (1999)	COI: Standford et al. (1999)	$4,339	$7,018	$5,710
	Hospital Admissions, Cardiovascular	Moolgavkar (2003); Moolgavkar (2000)	COI: med costs + wage loss	$148,188	$239,646	$194,448
	Hospital Admissions, Respiratory	Sheppard (2003); Ito (2003); Moolgavkar (2000)	COI: med costs + wage loss	$88,911	$143,816	$116,690

Total Annual Health Benefits

- Total health benefits for the state of Minnesota from the three policy scenarios in the years 2015 and 2025 are shown in the next slide.
- Note that these are not cumulative benefits, but predicted benefits in the modeled year (2015 or 2025).
- As expected, benefits increase over time. Consequently, benefits in 2025 are higher than those in 2015.
- Highest benefit of $550 MM is predicted for the Platform Case in 2025.

Total Value of Annual Health Benefits



Conclusions

- There are reductions in $PM_{2.5}$ for all policy scenarios
  - Largest reductions occur in the Cap-and-Trade Only Case in 2015.
  - Largest reductions occur in the Platform Case in 2025.
- Health incidence
  - Most benefit for both the Twin Cities and the rest of MN regions occur in the Cap-and-Trade Only Case in 2015.
  - Most benefit for both the Twin Cities and the rest of MN regions occur in the Platform Case in 2025.
- Health valuation
  - Value of health benefits is highest in the Cap-and-Trade Only Case in 2015 at $208 MM. 60% of this value is derived from avoided deaths.
  - Value of health benefits is highest in the Platform Case in 2025 at $550 MM. 60% of this value is derived from avoided deaths.

Summary and Conclusions

Economic Impacts – Conclusions

- Under the modeling assumptions used here, Minnesota's economy will continue to grow with the proposed Midwestern Accord, which caps GHG emissions in all Member states, including Minnesota
  - Rate of growth to be slightly lower than under the business-as-usual scenario (i.e., Reference Case).
  - Under the Reference Case, the state economy is projected to grow at about 3.16% annually between 2010 and 2030, compared to an annual growth rate of 3.11% to 3.14% under the Accord, depending on how the allowance revenues are recycled back.
- Under the scenarios analyzed here, Minnesota continues to create jobs at a robust pace with the Accord in place, but slightly lower than under the Reference Case
  - Under the Reference Case, the state is projected to add about 651,000 jobs between 2010 and 2030, compared to between 637,000 and 622,000, again depending on how the allowance revenues are recycled back into the economy.

Economic Impacts – Main Drivers

- Achieving goals set by the Complementary policies would be crucial in minimizing economic impacts on Minnesota residents
  - Under the modeling assumptions used here, the suite of Complementary policies could reduce costs by 20% - 30% in the long run. (this range is estimated using the GRP results for 2030 for the Platform Case, slide 77, and the Cap-and-Trade Only Case, slide 149).
- Impact of allowance revenue recycling could also be crucial in mitigating the costs of the policies
  - Negative impacts on GRP in Minnesota could be reduced by up to 70% by 2030, under our best-case allowance revenue recycling option (i.e., comparing the GRP impacts for 2030 under the hybrid and no revenue recycling options from slide 77).
  - Other revenue recycling options modeled in this study, though not as attractive, could reduce negative impacts by about 25% - 50% (i.e., comparing the other revenue recycling options with no RR from slide 77).

Economic Impacts – Distributional Effects

- Among the various industrial sectors, the utility sector would be affected the most in Minnesota, though the expenditures in cleaner generation under the Complementary policies cushion the losses in the rest of Minnesota region.
- By comparison, the construction sector could actually gain jobs under the public infrastructure and hybrid options, due to the significant investments in highway and mass transit infrastructure in the state.
- Consumption losses (see slide 91 for definition of consumption loss) for state residents could be less than 2% of their median income in 2030, under all of the revenue recycling assumptions
  - Consumption loss percentages are generally higher in the Twin Cities region compared to the rest of Minnesota. This is likely because the rest of Minnesota region benefits more from higher investments in cleaner generation and prices tend to go up more in urban areas (i.e., Twin Cities) than in semi-urban/rural areas.

Relative Impacts of Various Revenue Recycling Options

- Results for the per capita rebate, consumer and business incentives options are fairly comparable, with differences less than 10% (both for employment and GRP).
- The public infrastructure option provides slightly better results for employment as it supports more jobs in building/maintaining infrastructure.
- The worker retraining option could be the most attractive *individual* expenditure option and could be 20% - 40% better than just using rebates.

Percent Improvement of Various Revenue Recycling Options over Per Capita Rebate Option , 2030

	Employment	GRP
Consumer Incentives	3%	10%
Business Incentives	2%	1%
Public Infrastructure	15%	1%
Worker Retraining	18%	32%
Hybrid Option	56%	65%

- The hybrid option, as modeled here, could be the most promising in reducing the costs of the cap-and-trade program. This option could be over 65% more effective than the per capita rebate option.

Relative Impacts of Various Revenue Recycling Options, cont.

- **These results indicate**
  - That the macroeconomic effects of the per capita rebate, consumer and business incentives options could be quite similar for the state, although individually they may benefit one group at the cost of another (i.e., lead to transfers across groups).
  - Investing the allowance revenues in public infrastructure projects that reduce emissions could be more effective (than those mentioned above) if the goal is to minimize job losses.
  - Investing in worker retraining could be just as effective in minimizing job losses, but with the added benefit of generating higher economic output because of the higher skill levels of the retrained workforce and their effect on worker productivity.
  - A hybrid option could be the most effective way to achieve the goals set forward in the Minnesota Green Solutions Act since it provides relief to multiple sectors. Thus, developing revenue expenditure approaches that target multiple sectors simultaneously should be given careful consideration in order to reduce impacts on state residents.

Economic Impacts – Some Caveats

- Our modeling of the Reference Case in REMI did not include the "cost of inaction"
  - Cost of inaction is defined as the costs the economy could face (in terms of lost GDP, etc.), if we continue on the current business-as-usual path with no action on reducing GHG emissions.
- Our modeling also did not incorporate potential CO2 restrictions from EPA's rules following the endangerment finding
  - EPA is on course to begin regulating GHGs by 2011.
  - While the impacts of national-level EPA regulations on a regional program such as this are uncertain, it will have some effect on the Reference Case assumptions, that were not incorporated here.

Health Benefits – Conclusions

- GHG policy scenarios under the Midwestern Accord lead to reductions in criteria pollutant emissions and changes in the geographic location of emission sources
  - Emission reductions in criteria pollutants result in improved air quality and corresponding health benefits for Minnesota residents.
  - In order to quantify those health benefits, we conducted air quality modeling with CALPUFF—an EPA-approved air quality model for long range transport of pollutants—to predict ambient concentrations from each of the policy scenarios.
  - We then estimated health benefits from change in ambient concentrations of criteria pollutants using valuation methods established through EPA's BenMAP (Benefit Mapping and Analysis Program) model.

Health Benefits – Changes in Air Quality

- When compared with the Reference Case, the maximum decrease in criteria pollutant emissions from electric generating units is about 10% in 2015 and nearly 30% in 2025 across all policy scenarios
  - Largest reduction in criteria pollutant emissions could come from the Cap-and-Trade Only Case in 2015 and from the Platform Case in 2025.
- All criteria pollutant emissions could decrease by 15% – 30%, compared to the Reference Case by 2025.
  - Within Minnesota, largest reductions in criteria pollutants come from the Twin Cities region; and outside MN, they occur in Iowa.
- Our air quality modeling indicates the emission reductions could lead to corresponding decreases in ambient concentrations
  - Largest reduction in region-wide average $PM_{2.5}$ is nearly 10% in 2015 under the Cap-and-Trade Only Case and nearly 30% in 2025 under the Platform Case. A large fraction of these reductions are attributed to reductions in secondary particulate nitrate.

Health Benefits – Valuation

- Using BenMAP, we estimated the change in the number of incidences of the following health endpoints: Pre-mature deaths (mortality), work loss days, emergency room visits for respiratory causes, hospital admissions for cardiovascular conditions, hospital admissions for respiratory conditions, asthma exacerbation, and chronic bronchitis.
- The decrease in the number of adverse health incidences corresponds to the decrease in ambient concentrations which in turn corresponds to the decrease in criteria pollutant emissions under various policy scenarios.
- Using EPA's economic valuation functions, the value of health benefits due to the reduction in air emissions by implementation of the Platform Case was estimated to be $550 million (annual dollars) in 2025, (for e.g., see slide 123).

Appendix A : Minnesota Green Solutions Act Legislation

Minnesota Green Solutions Act Legislation

An act relating to environment; establishing the Legislative Greenhouse Gas Advisory Group; requiring studies and reports to the legislature regarding cap and trade program for greenhouse gases; appropriating money.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. TITLE.

This act may be cited as the Green Solutions Act of 2008.

Sec. 2. MIDWESTERN GREENHOUSE GAS ACCORD

(a) By January 15, 2009, the commissioner of commerce and the commissioner of the Pollution Control Agency shall submit a report to the chairs and ranking minority members of the senate and house of representatives committees with primary jurisdiction over energy policy, business and economic development policy, environmental policy and finance, and transportation policy regarding:
(1) the status of the development of a model rule establishing a regional cap and trade program under the Midwestern Greenhouse Gas Accord;
(2) implementation mechanisms in the model rule, including required legislation;
(3) whether the regional cap and trade program will operate in a time frame that will allow Minnesota to meet the greenhouse gas reductions goals under Minnesota Statutes, section 216H.02, subdivision 1;
(4) an evaluation of legislation enacted or pending in Congress to implement a federal cap and trade program and whether implementation of a regional program is consistent with a federal program;
(5) the economic, environmental, and public health impact study under section 3, subdivision 2; and
(6) a potential cap and trade revenue study under section 3, subdivision 3.

If a model rule in accord with the state's emissions reduction goals is not yet ready for adoption under the Midwestern Greenhouse Gas Accord, or is unlikely to be adopted, the report must identify options for Minnesota to supplement the regional agreement with state policies, to join another regional cap and trade program, or to implement a cap and trade program in Minnesota alone.

Minnesota Green Solutions Act Legislation

(b) The Legislative Greenhouse Gas Accord Advisory Group is composed of six members of the legislature, appointed as follows:

(1) three members of the senate appointed by the Subcommittee on Committees of the Committee on Rules and Administration, including one member of the minority; and

(2) three members of the house of representatives appointed by the speaker of the house of representatives, including one member of the minority party. The legislative advisory group serves in an advisory capacity to the governor's Midwestern Greenhouse Gas Accord stakeholder group, and must receive regular briefings from that group, in addition to participating and offering advice in meetings where regional negotiations take place with respect to the accord or to any other energy issue being analyzed by an entity created by the Midwestern Governors Association at its November 2007 Energy Summit. The appointing authorities under this paragraph must complete their appointments by June 1, 2008. The advisory group expires when the Midwestern Greenhouse Gas Accord stakeholder group is dissolved.

(c) Any cap and trade agreements entered into under the Midwestern Greenhouse Gas Accord are not effective in Minnesota until approved by a law enacted by the legislature.

Minnesota Green Solutions Act Legislation

Sec. 3. ECONOMIC, ENVIRONMENTAL, AND PUBLIC HEALTH IMPACT AND POTENTIAL REVENUES STUDIES.

Subdivision 1. Submission of studies. By January 15, 2009, the commissioner of commerce and the commissioner of the Pollution Control Agency shall submit to the chairs and ranking minority members of the senate and house of representatives committees with primary jurisdiction over business and economic development, energy, and environmental policy and finance the two studies, prepared by expert consultants, described in this section.

Subd. 2. Economic, environmental, and public health impact study. The commissioner of commerce shall arrange with the Midwestern Governors Association for a study to be conducted by expert consultants that analyzes the economic, environmental, and public health costs and benefits to Minnesota of a cap and trade program. The study must consider the impact of a cap and trade program on individual industrial sectors subject to the program and on the state economy and consumers, and how expenditures of any auction revenues on the measures identified in subdivision 4 can reduce the economic costs and increase the economic, environmental, and public health benefits. The study must also include:

(1) an estimate of allowance prices and rates of investment by entities subject to a cap and trade program in infrastructure and equipment to reduce emissions of greenhouse gases over time;
(2) estimates of the impact of the program on energy costs, the impact of energy cost changes on businesses and households, and recommendations on how to avoid regressive impacts;
(3) an analysis of options to mitigate adverse competitive impacts on state businesses and methods to reduce disruptive impacts on workers, businesses, and consumers;
(4) an analysis of various mechanisms for protecting jobs in energy intensive industries subject to competition from outside the Midwestern Greenhouse Gas Accord region, including mining, pulp and paper, petroleum refining, steel, and chemicals, and an analysis of possible mechanisms to account for the greenhouse gas emissions associated with the production and transportation of imported goods;
(5) an analysis of the energy cost impacts on homes and businesses, job growth, new business development, energy balance of trade, and environmental and public health co-benefits;
(6) an analysis of various mechanisms to provide for equity to communities at risk of disproportionate economic or environmental impacts; and
(7) an analysis of the effect of adopting a cap and trade program on the level of foreign and domestic investment in Minnesota.

The study must consider the data and policy recommendations developed through the Minnesota Climate Change Advisory Group as well as the growing literature related to reducing greenhouse gas emissions.

Minnesota Green Solutions Act Legislation

Subd. 3. **Potential cap and trade revenue study.**

The commissioner of commerce shall arrange with the Midwestern Governors Association for a study to be conducted by expert consultants on potential revenues to the state from a cap and trade program and how revenues could be spent to mitigate economic disparities resulting from implementation of a cap and trade program. The study must include:

(1) projections of likely revenues if greenhouse gas emission allowances are auctioned;

(2) a detailed estimate of the degree to which different levels of expenditures of auction proceeds on the options listed under subdivision 4, clauses (1) through (7), would:

(i) reduce greenhouse gas emissions;
(ii) reduce economic costs to industry and households;
(iii) yield jobs and other economic benefits by stimulating economic activity, promoting the growth of new businesses, reducing the amount of money exported from the state to purchase fossil fuels, and other means;
(iv) result in environmental and public health co-benefits by reducing pollutants other than greenhouse gases, improving habitat, or other means; and
(v) otherwise meet the goals identified in subdivision 5;

(3) a discussion of the potential for allowances allocated by a cap and trade program to lead to unfair economic advantage or windfall profits rather than be used to reduce consumer prices; and

(4) options for criteria that decision makers can use to determine how to allocate expenditures among the spending options listed under subdivision 4, balancing the goals set forth in subdivision 5.

Minnesota Green Solutions Act Legislation

Subd. 4. **Expenditures to be studied.** The studies required under subdivisions 2 and 3 must consider the impacts of the following types of expenditures:

(1) direct per capita rebates to Minnesotans;

(2) grants and incentives to consumers to invest in energy efficiency and utilize renewable energy sources or in other technologies, products, or practices that help Minnesotans reduce energy costs, energy consumption, and greenhouse gas emissions, including incentives for telecommuting;

(3) financial assistance to businesses that install technologies that reduce greenhouse gas emissions, targeting energy-intensive industries facing competitors not subject to comparable regulation, including, but not limited to, mining, pulp and paper, refining, chemicals, and steel;

(4) investments in public infrastructure that reduce greenhouse gas emissions;

(5) investments in worker training and retraining programs;

(6) incentives for terrestrial and geologic carbon sequestration; and

(7) at least one scenario in which a majority of expenditures is directed to uses under clauses (1) and (2).

Minnesota Green Solutions Act Legislation

Subd. 5. **Study criteria.**

The study required under subdivision 2 must determine the extent to which expenditures on the measures identified in subdivision 4 assist Minnesota in its transition to a low greenhouse gas-emitting economy and increase the economic gains and reduce the dislocating impacts of the transition. Specifically, the study must assess the extent to which expenditures meet the following goals:

(1) produce cost-effective emission reductions;

(2) increase sustainable economic development, job creation, and job growth;

(3) reduce greenhouse gas emissions in sectors that do not participate in a cap and trade program;

(4) reduce disruptive economic impacts of the transition on workers, businesses, and consumers;

(5) equitably distribute the costs and benefits among state residents, communities, and economic sectors;

(6) assist low-income and other consumers to reduce the costs associated with greenhouse gas emissions; and

(7) protect and enhance public health, environmental quality, wildlife habitat, and the state's natural resources.

Minnesota Green Solutions Act Legislation

Sec. 4. **GOVERNANCE STUDY.**

The commissioner of commerce shall request the Board of Regents of the University of Minnesota to prepare a study to be submitted by January 15, 2009, to the chairs and ranking minority members of the senate and house of representatives committees with primary jurisdiction over business and economic development, energy, and environmental policy and finance on governance options for determining expenditures of potential revenue to the state resulting from a cap and trade program. The study must examine:

(1) the role of the legislature, citizens, technical experts, and state agencies in decisions on allocating funds; and

(2) innovative decision-making structures and processes, including the Legislative-Citizen Commission on Minnesota Resources, and other examples in Minnesota and other states and countries that may offer useful models.

Minnesota Green Solutions Act Legislation

Sec. 5. **APPROPRIATION.**

Of the amounts appropriated from the special revenue fund in the second year to the commissioner of commerce under Laws 2007, chapter 57, article 2, section 3, subdivision 6, clause (7), up to $500,000 is for the economic impact and potential revenue studies under section 3, and the governance study under section 4. The commissioner shall provide funding from this appropriation through a contract with the Midwestern Governors Association for grants to technical experts to complete the studies required under section 3. The commissioner shall transfer up to $75,000 to the University of Minnesota for the study required under section 4.

Presented to the governor May 15, 2008

Signed by the governor May 19, 2008, 11:13 a.m.

Appendix B: Additional REMI Modeling Results for the Cap-and-Trade Only Runs

Cap-and-Trade Only Runs: Introduction

- Under the Midwestern Accord modeling study, sensitivity runs were conducted for a Cap-and-Trade Only Case without the Complementary policies in place.
- This Appendix discusses the economic impacts for those runs and the corresponding revenue recycling scenarios
  - **Per Capita Rebates** – Lump sum, direct per–capita rebates to all Minnesotans.
  - **Consumer Incentives** – Grants or incentives to consumers to encourage investment in energy efficiency or renewable technologies that help reduce energy costs and consumption for Minnesotans.
  - **Business Incentives** – Financial incentives for businesses to install GHG reducing technologies, focusing primarily on energy intensive industries.
  - **Public Infrastructure** – Investments in public infrastructure designed to reduce GHG emissions.
  - **Worker Retraining** – Investment in retraining of workers who lost their job, as well as financial incentives to business for hiring newly trained workers.
  - **Hybrid** – Allowance revenues are split equally between Consumer Incentives, Business Incentives, Public Infrastructure Investment and Worker Retraining programs.
  - **No Revenue Recycling –** assumes no revenue recycling, provides comparison to MGA runs.

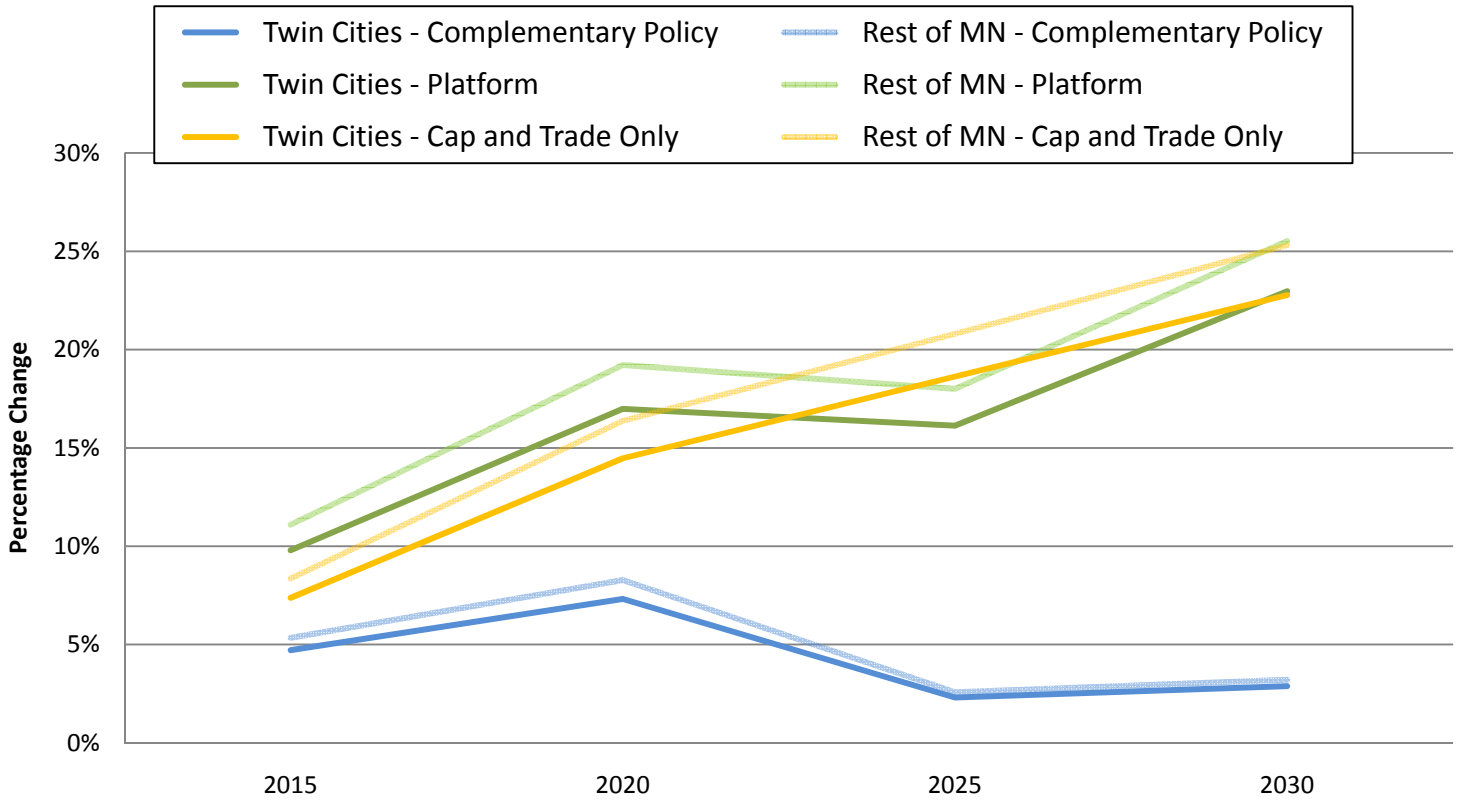
Methodology

- Most of the revenue recycling options modeled under the Cap-and-Trade Only scenarios are similar to the approach discussed above for the Platform Case
  - Per Capita Rebates
    - Allowance revenue amounts available for recycling are different because of higher allowance prices (see slide 148 for the revised amounts).
  - Consumer Incentives
    - Although these runs do not include Tier II Complementary policies, it uses IPM assumptions on energy efficiency. Economic modeling accounted for these changes, especially in retail rates, and the corresponding resources needed to fund these EE programs.
  - Business Incentives
    - Used the same nine energy-intensive sectors and provided them free allocation under this option. Rest of the revenue amounts recycled back as per capita rebates.

Methodology, cont.

- Public Infrastructure
  - Same assumptions as with the Platform Case.
- Worker Retraining
  - Estimated job losses by occupation categories that were higher than those under the Platform Case (without the Tier II Complementary policies). Cost impacts–-both in terms of job losses and economic output—are generally higher under the Cap-and-Trade only Case. Used allowance revenues to retrain and incentivize hiring of laid-off workers.
- Hybrid Option
  - Assumed available allowance revenues are used in equal amounts for the four revenue recycling options (consumer and business incentives, public infrastructure and worker retraining and rehiring).

Percentage Change in Electricity Price Compared to the Reference Case



Cap-and-Trade Only Runs – Allowance Revenue Amounts

- Both the Platform Case and the Cap-and-Trade Only Case are likely to generate significant amounts through allowance auctions and fixed fees.
- Much higher amount of allowances in the Cap-and-Trade Only Case compared to the Platform Case.

	Platform		Cap and Trade	
	2020	**2030**	**2020**	**2030**
Twin Cities	391	849	710	1,808
Rest of MN	245	514	445	1,094
Total	**636**	**1,363**	**1,155**	**2,902**

  - Allowance revenues are almost 2:1 greater in the Cap-and-Trade Only Case compared to the Platform Case in 2020, and greater than 2:1 in 2030.
  - Thus, the impacts of revenue recycling on these runs are likely to be larger than those under the Platform Case, all else equal.

Cap-and-Trade Only Case: Summary Results – Percentage Change from Reference Case

- The table below summarizes the incremental impacts from the Reference Case for the various cap-and-trade only REMI runs

	Employment		GRP	
	2020	2030	2020	2030
No Revenue Recycling	-0.73%	-1.39%	-0.85%	-1.70%
Per Capita Rebates	-0.35%	-0.67%	-0.53%	-1.08%
Consumer Incentives	-0.34%	-0.61%	-0.51%	-1.03%
Business Incentives	-0.34%	-0.60%	-0.52%	-1.01%
Public Infrastructure	-0.28%	-0.43%	-0.53%	-1.03%
Worker Retraining	-0.31%	-0.59%	-0.33%	-0.85%
Hybrid Option	-0.25%	-0.22%	-0.19%	-0.37%

Cap-and-Trade Only Case: Summary Results – Percentage Change from Reference Case, cont.

- As before, differences among the various revenue recycling options (except the hybrid option) are fairly small but are helpful in determining the relative impacts across options.
- Without any revenue recycling (i.e. No Revenue Recycling option), impacts under the Cap-and-Trade Only Case are consistently higher than those under the Platform Case. This is expected since the Cap-and-Trade Only Case excludes the Complementary policies that helped keep the cost of the program down under the Platform Case.
- Results for most of the revenue recycling options are slightly better with the Cap-and-Trade Only Case runs when compared to the corresponding Platform Case runs. This is mainly due to the substantially higher allowance revenue amounts available under the Cap-and-Trade Only scenario (because of much higher allowance prices). The positive effects of these higher revenue amounts outweigh the negative effects of the lack of Complementary policies for these runs, especially in early years (i.e., through 2020).

Cap-and-Trade Only Case – Percent Improvement from Per Capita Rebate Scenario

- The tables show how much better each of the revenue recycling options are relative to the per capita rebate option. Results here are consistent with the trends for the Platform Case runs.
- The per capita rebate, consumer and business incentives options are generally comparable, with differences of 10% or less.
- Employment impacts under the public infrastructure option are slightly higher than those under the Platform Case. This is also likely due to the substantially higher investments possible under this option with the higher allowance revenues available.
- Consistent with the previous finding, the hybrid run outperforms the other options because of this scenario's impacts on multiple affected sectors.

2020

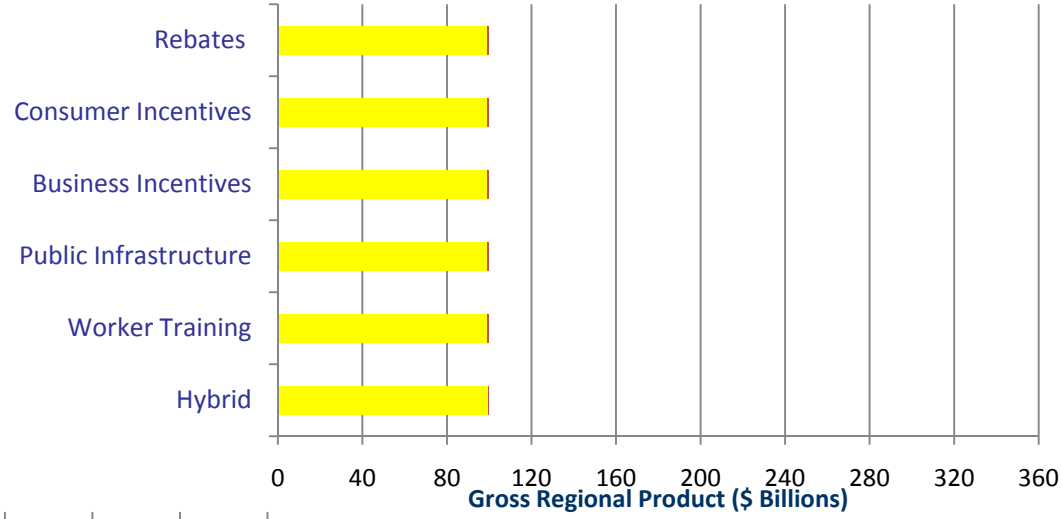
	Employment	GRP
Consumer Incentives	3%	4%
Business Incentives	3%	2%
Public Infrastructure	20%	0%
Worker Retraining	11%	38%
Hybrid Option	29%	64%

2030

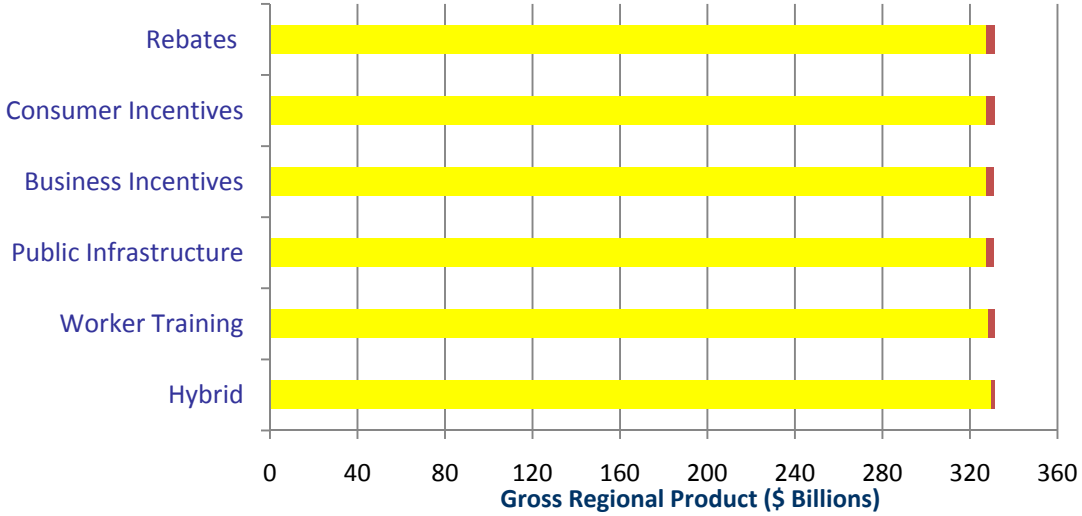
	Employment	GRP
Consumer Incentives	9%	5%
Business Incentives	10%	6%
Public Infrastructure	36%	5%
Worker Retraining	12%	21%
Hybrid Option	67%	66%

Gross Regional Product Forecasts for 2030

Rest of MN



Twin Cities MSA



- GRP losses for the individual revenue recycling options (the red tips in each bar) are fairly small across the options, for both regions, consistent with trends under the Platform Case.
- Impacts are slightly larger here than under the Platform Case.

Employment

- The table shows the incremental jobs created under various scenarios, including the Reference Case and the different revenue recycling options, under the Cap-and-Trade Only Case.
- Jobs created under the No Revenue Recycling option are similar in 2020 but about 13,000 lower by 2030, since the Complementary policies lead to positive job gains in the long run, under the Platform Case.
- Total number of jobs created under the various revenue recycling options are again similar across the options, but slightly higher than the corresponding numbers under the Platform Case. This is also due to the substantially higher levels of expenditures possible with the available allowance revenues.

Number of Jobs Created since 2010 (in Thousands) – Cap-and-Trade Runs		
	2020	**2030**
Reference Case	320	651
No Revenue Recycling	292	594
Per Capita Rebates	306	624
Consumer Incentives	307	626
Business Incentives	307	627
Public Infrastructure	309	634
Worker Training	308	627
Hybrid Option	310	642

Comparing Economic Impacts: Platform vs. Cap-and Trade Only Cases

- Without the benefits of revenue recycling, GRP impacts under the Platform Case are better (about -1.3% change from Reference Case) than the Cap-and Trade Only Case (about -1.7% change from Reference Case). This is expected because the Platform Case includes the benefits of the Complementary policies.
- However, when revenue recycling is thrown into the mix, the gap between the two scenarios diminish, as the positive impacts of the substantially higher allowance revenue amounts under the Cap-and-Trade Only Case masks the negative effects of the lack of Complementary policies. Thus, under most of the revenue recycling options, Platform and Cap-and-Trade Only results seem comparable at the state-level.