Employment Impacts of Climate Action Plans

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Climate Policy Employment Impacts

- For many years these impacts deemed redundant
- Several reasons for increasing attention
  - may move in opposite direction of GDP impacts (labor-intensiveness of renewable energy implementation)
  - important in their own right (human self-worth)
  - job quality and pay issues
  - institutional considerations (unions, training)
  - major link to income distribution (equity and justice)
- Focal point of major debate: Panacea or Job-Killers

Overview

- Summary of Climate Action Plan job impact results
- Estimation processes and modeling approaches
- Rationale for estimating indirect job impacts
- REMI Model
- Detailed analysis of results (LA100 Study)
- Interesting findings (causal factors, sensitivities)
- Conclusions and future research

GHG Mitigation Action Plans

- Definition: Framework for organizing and evaluating tactics to reduce greenhouse gas emissions

- Consists of various components:
  - incentive-based instruments
    - -- cap & trade
    - -- taxes/subsidies
  - regulations
    - -- renewable portfolio standards
    - -- residential/commercial/industrial demand-side mgt
    - -- transportation and land-use
    - -- agriculture/forestry/waste management

Macroeconomic Impacts of CAPs

Studies	Base Case(s) GRP Impact in Target Year	Base Case(s) Employment Impact in Target Year
Michigan Department of Environmental Quality; Stationary + Mobile Sources (2009-25)	2.30%	2.70%
Wisconsin Public Service Commission; Stationary + Mobile Sources (2011-25)	0.62%	0.56%
New Mexico Environmental Improvement Board; C&T + Complementary Policies (2010-20)	-0.26% to 0.22%	-0.56% to 0.22%
Pennsylvania Department of Environmental Protection; Stationary + Mobile Sources (2009-20)	0.31%	0.52%
New York Energy Research & Development Authority; Stationary + Mobile Sources (2011-30)	0.31%	0.56%
Florida Governor's Office; Stationary + Mobile Sources (2008-25)	0.87%	1.13%
California (Next 10); C&T + Complementary Policies (2020-45)	0.2% to 0.5%	0.4% to 0.6%
Southern California Association of Governments; Stationary Sources (2013-35)	-0.06%	0.49%
Southern California Association of Governments; Transportation & Land Use (2013-35)	0.17%	0.19%
Baja California (Border Environ Cooperation Commission); Stationary + Mobile Sources (2015-30)	-0.02%	0.08%
City of LA (LADWP/NREL); 100% Renewable Electricity (2026-45)	-0.63% to 0.54%	-0.21% to 0.34%

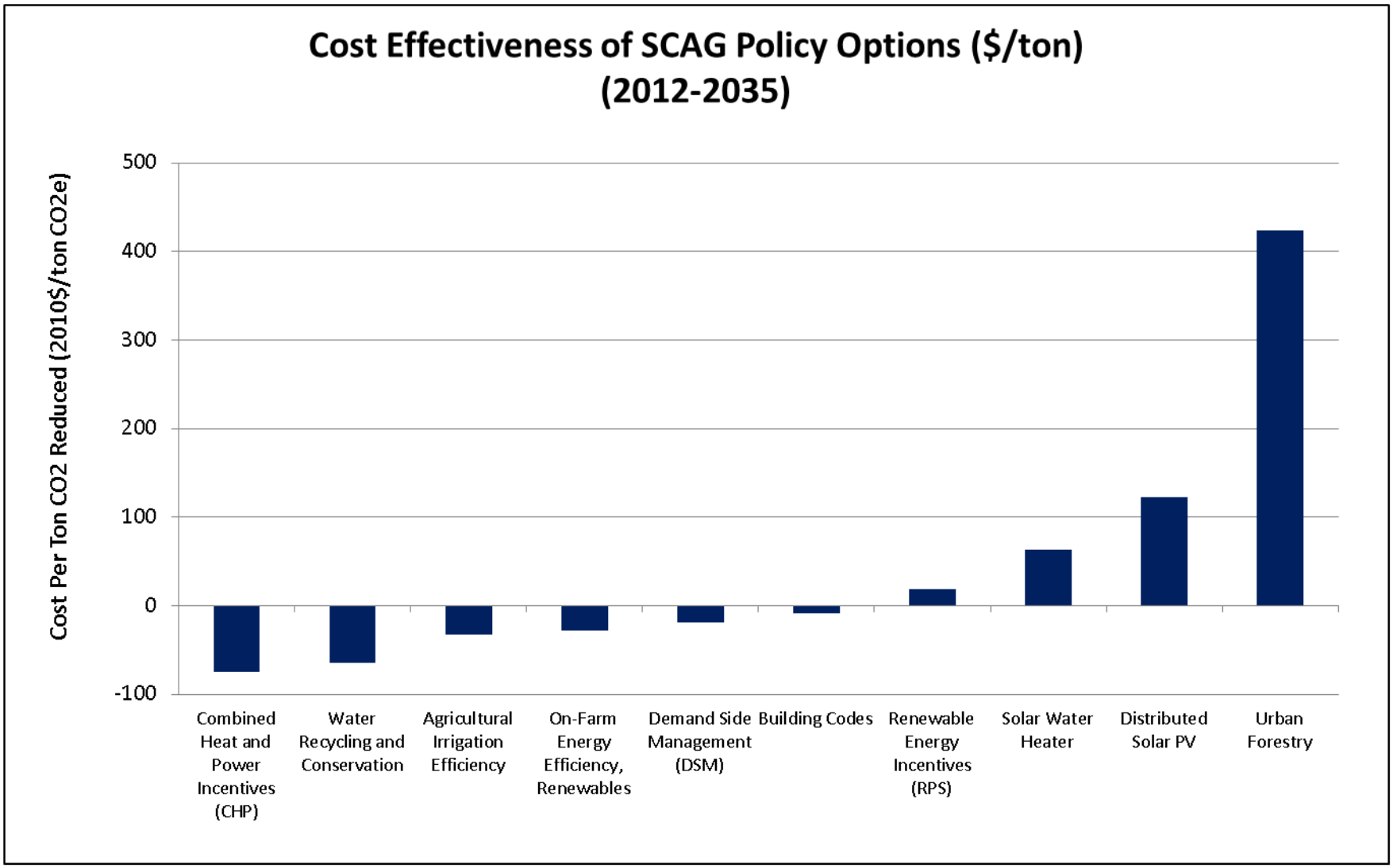
Estimation Process

- Direct (micro) estimation of cost-effectiveness
  - direct cost of each mitigation/sequestration tactic
  - amount of GHGs that can be reduced by each tactic
- Direct estimation of employment impacts
  - secondary data or use of employment/output ratios
  - more sophisticated analyses (e.g. NREL JEDI)
- Economy-wide (macro) impacts
  - input-output analysis
  - computable general equilibrium analysis
  - macroeconometric analysis
- REMI Model used in most cases

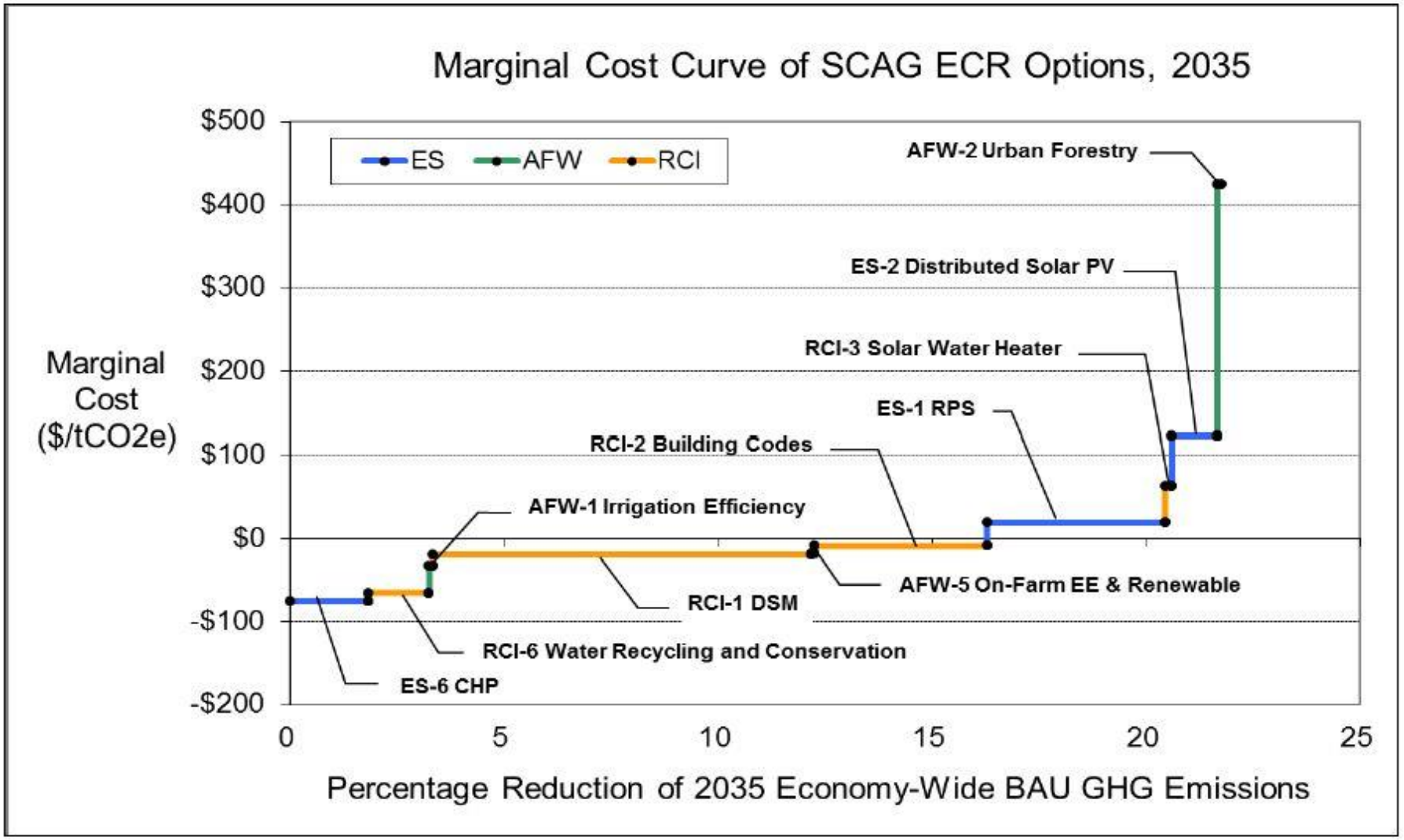
SCAG Microeconomic Impacts of GHG Mitigation Policy Options

Policy Option Number	Policy Option Description	2012-2035 (MMtCO2e)	Net Present Value (million 2010$) 2012-2035 Cost / Cost Savings	Cost-Effective-ness ($/tCO2e)
RCI-1	Utility Demand Side Management (DSM) Programs for Electricity and Natural Gas Utilities), and/or Energy Efficiency Funds	297	-5,652	-19
RCI-2	Improved Building Codes for Energy Efficiency	119	-1,025	-9
RCI-3	Incentives for Renewable Energy Systems at Residential, Commercial, and Industrial Sites	5.1	325	63
RCI-6	Increase Water Recycling and Water End-use Efficiency and Conservation Goals and Programs	54	-3,528	-65
ES-1	Central Station Renewable Energy Incentives including Project Development Barrier Removal Issues	265	5,025	19
ES-2	Customer Sited Renewable Energy Incentives and/or Barrier Removal	37.5	4,624	123
ES-6	Combined Heat and Power (CHP) Incentives and/or Barrier Removal, including Co-location or Integration of Energy-Producing Facilities	66.2	-4,971	-75
AFW-1	Improve Agricultural Irrigation Efficiency	4.4	-145	-33
AFW-2a	Improve Urban Forestry and Green Space Management through Expansion and Effective Management: Urban Forestry	2.7	1,359	424
AFW-5a	Increase On-Farm Energy Efficiency & Renewable Energy Production: Renewable Energy	0.65	-6	-9
AFW-5b	Increase On-Farm Energy Efficiency & Renewable Energy Production: Energy Efficiency	2.3	-47	-28
	Total After Overlap Adjustments	**853**	**-3,157**	**-4**

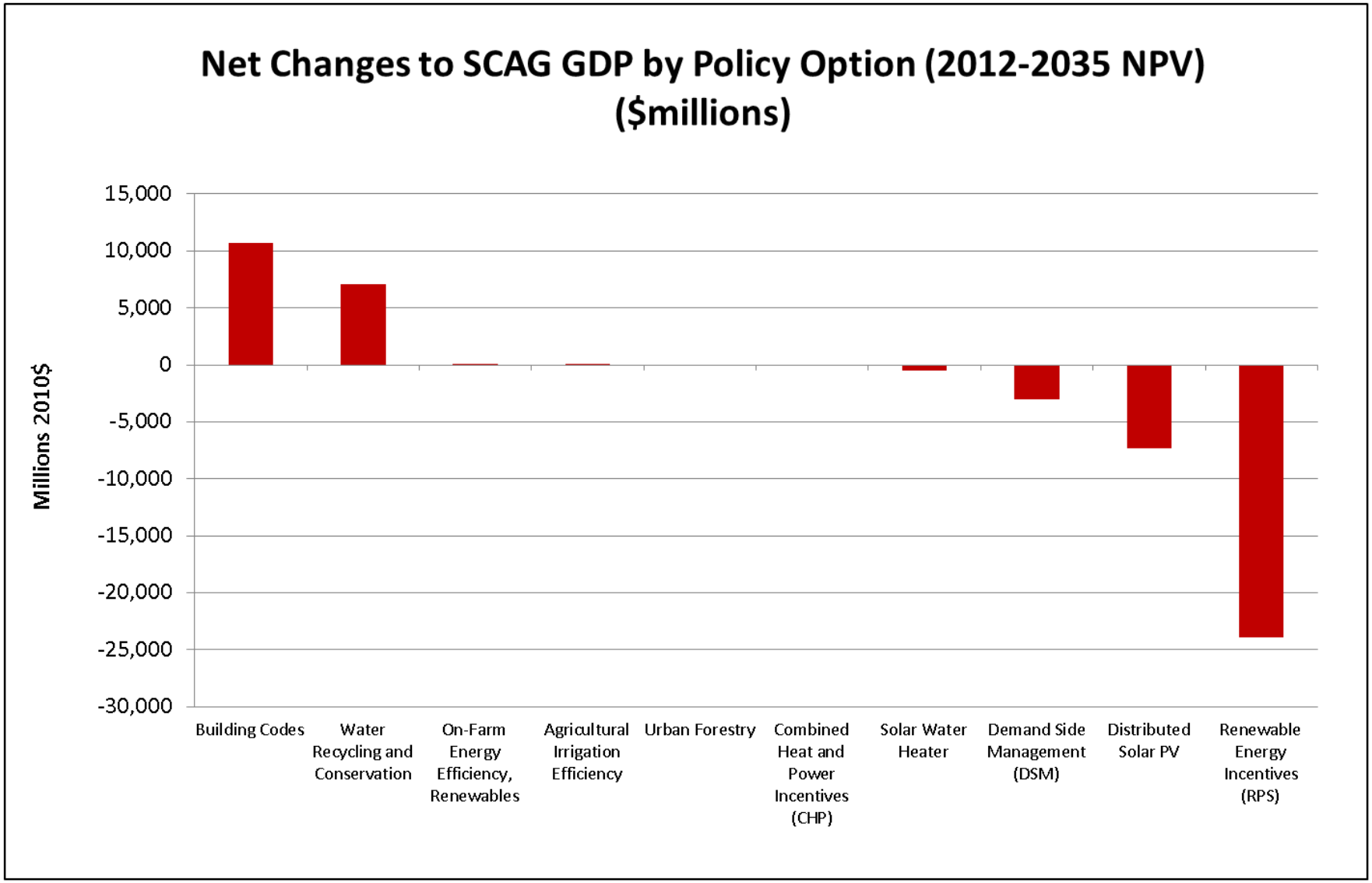
Cost-Effectiveness of GHG Mitigation Policy Options



SCAG Marginal Cost Curve of Mitigation Policy Options



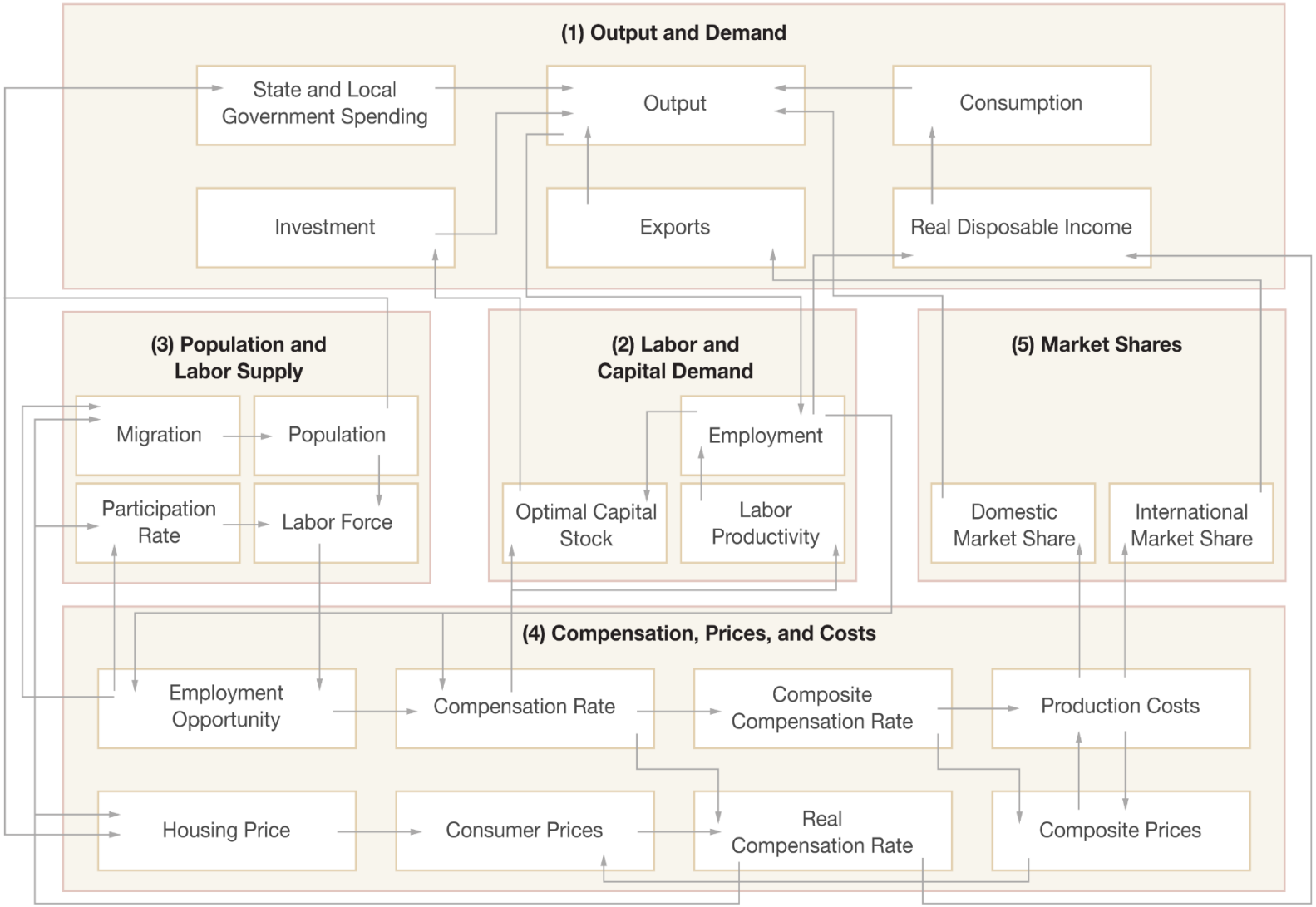
SCAG GDP Impact Results



Overview of the REMI Model

- Regional Economic Models, Inc. (REMI) has evolved over 30 years
- One of the most widely used state level and national level macroeconomic modeling tools in the U.S.
- Sectoring scheme: 169 sectors
  - 83 manufacturing sectors
  - 6 energy sectors
  - 8 transportation sectors
  - 59 commercial and services sectors
  - 13 other sectors

REMI Model Structure



Input Data for Mitigation Analysis

- Major data sources for macro impact analysis are microeconomic quantification results on the direct costs and savings of the mitigation policy options:
  - Change in upfront capital investment by sector
  - Change in annualized capital cost by sector
  - Change in O&M expenditure by sector
  - Change in fuel expenditures by fuel type by sector
  - Program implementation, administrative costs, and any other relevant costs to the option
  - National or state subsidies/tax credits
  - Other assumptions of funding sources

Linkages of Micro Analysis Results and REMI Modeling Inputs

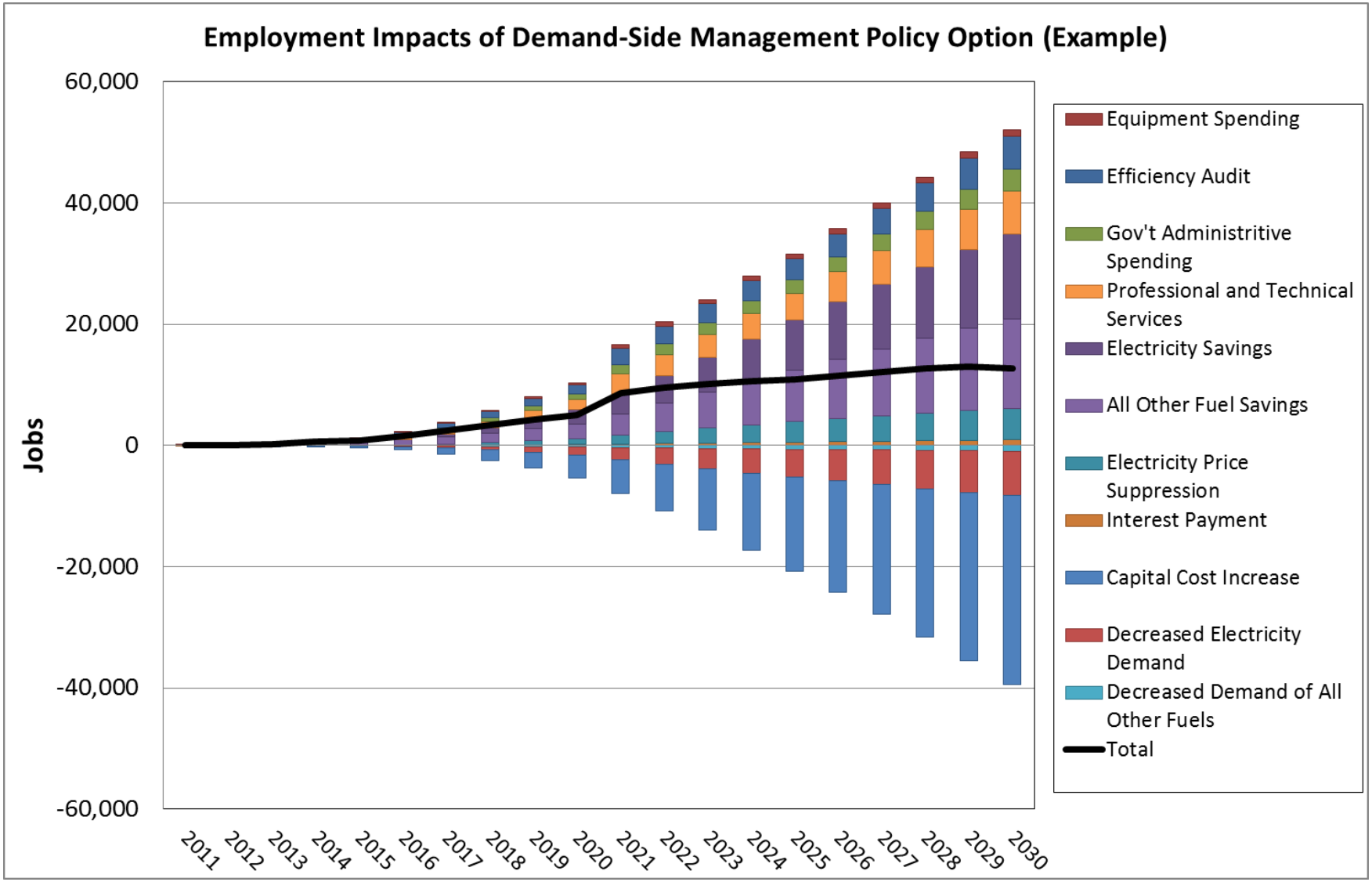
(DSM example)

	Direct Economic Impact		Policy Variable Selection in REMI
Positive Stimuli	Increased Spending on EE Technologies and Equipment		Output and Demand Block →Exogenous Final Demand (amount) for Ventilation, Heating, Air-conditioning, and Commercial Refrigeration Equipment Mfg sector, Industrial Machinery Mfg sector, Commercial and Service Industry Machinery Mfg sector, Audio and Video Equipment Mfg sector, Electric Lighting Equipment Mfg sector, Household Appliance Mfg sector, Electrical Equipment Mfg sector, and Other Electrical Equipment and Component Mfg sector→Increase
	Increased Demand of Efficiency Audit		Output and Demand Block →Exogenous Final Demand (amount) for Construction sector→Increase
	Administrative Spending		Output and Demand Block →Exogenous Final Demand (amount) for Electric Power Generation Sector →Increase
	Professional and Technical Services Spending		Output and Demand Block →Exogenous Final Demand (amount) for Management, Scientific, and Technical Consulting Services sector→Increase
	Energy Savings of the Customers	Businesses (Commercial and Industrial Sectors)	Compensation, Prices, and Costs Block→ Electricity and Natural Gas (Commercial Sectors) Fuel Cost (amount) of Individual Commercial and Industrial Sectors→Decrease
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount)→All Consumption Sectors →Increase
	Increased Demand of Services from Financial Sector		Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase
Negative Stimuli	Customer Outlay on Energy Efficiency (EE)	Businesses (Commercial and Industrial Sectors)	Compensation, Prices, and Costs Block →Capital Cost (amount) of Individual Commercial and Industrial Sectors→Increase
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount)→All Consumption Sectors →Decrease
	Energy Demand Decrease from the Energy Supply Sectors		Output and Demand Block →Exogenous Final Demand (amount) for Electric Power Generation, Transmission, and Distribution sector; Natural Gas Distribution sector; Coal Mining sector; and Petroleum and Coal Products Manufacturing sector→Decrease

REMI Macro Modeling Output

- Impacts on major macroeconomic indicators (GDP, employment, output, personal income, price index)
- Impacts by year throughout the planning horizon
- Impacts by sector
- Aggregate impacts of each policy option
- Decomposed impacts of each policy option: impacts in terms of the various economic factors that affect the bottom-line for each option

REMI Modeling Output—Decomposition Analysis



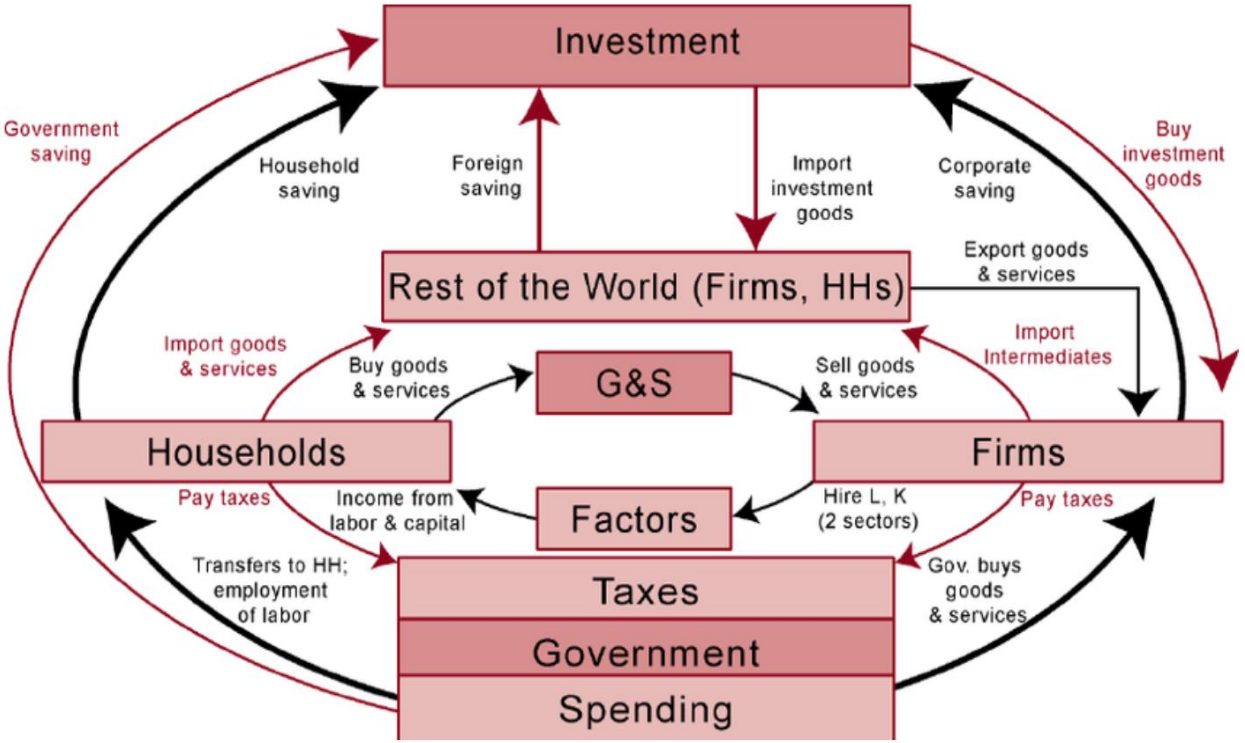
LA 100 Economic Impact Study

- City of LA plans to modernize its electricity infrastructure by 2045:
  - 100% renewable electricity
  - Aggressive electricity targets for buildings and vehicles
- Consistent with California Senate Bill 100: zero-carbon resource supply of retail electricity by 2045
- Considering 9 major electricity modernization scenarios
- Large-scale study with many areas of analysis:
  - engineering
  - economic impact
  - environmental impact
  - stakeholder impact

LA 100 Scenarios

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load Stress
		SB100	Early and No Biofuels	Transmission Focus	Limited New Transmission	SB100	Early and No Biofuels	Transmission Focus	Limited New Transmission	SB100
	RE Target in 2030 with RECs	60%	100%	100%	100%	60%	100%	100%	100%	60%
	Compliance Year for 100% RE	2045	2035	2045	2045	2045	2035	2045	2045	2045
Technologies that do not vary in eligibility across scenarios	Solid Biomass	N	N	N	N	N	N	N	N	N
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	RE-derived Hydrogen Combustion	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geothermal	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technologies that do vary	Biofuel Combustion	Y	No	Y	Y	Y	No	Y	Y	Y
	Natural Gas	Y	No	No	No	Y	No	No	No	Y
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors

CGE Model Flow Diagram



- Models the economy as a set of interrelated supply chains
- Mimics role of markets & prices

Absolute and Relative Analysis

- **Scenario Analysis Decisions**
  - Electricity infrastructure and prices will not stagnate in the future
  - Basic changes already set in motion
  - Holding prices constant at Year 2020 levels would be misleading
- **Used SB100–Moderate as a minimal compliance (reference) scenario**
  - But also calculated impacts in relation to 2020 constant electricity prices

Net Employment Impacts of the LA100 Scenarios

(relative to SB100-Moderate)

	Annual Average, 2026 to 2030		Annual Average, 2041 to 2045	
	Employment	Percent Change	Employment	Percent Change
SB100 - Moderate	n.a.	n.a.	n.a.	n.a.
SB100 – High	2,200	0.13%	3,500	0.19%
SB100 – Stress	3,000	0.17%	6,000	0.33%
Early & No Biofuels – Moderate	-2,500	-0.14%	-3,900	-0.22%
Early & No Biofuels – High	300	0.02%	-760	-0.04%
Transmission Focus – Moderate	1,700	0.09%	-800	-0.04%
Transmission Focus – High	1,700	0.10%	3,300	0.18%
Limited New Transmission – Moderate	5	0.00%	2,300	-0.13%
Limited New Transmission – High	2,200	0.12%	4,100	0.23%

- Largest projected **increase**: SB100-Stress
- Largest projected **decrease**: Early & No Biofuels–Moderate
- Time-paths of changes affected by combination of 3 causal factors
- Percentage changes are relatively small

Income Distribution Impacts SB100–High Example

- All numbers are positive, indicating increased aggregate income compared to SB100–Moderate scenario
- Lower-income households receive a higher proportion of increased income
  - Relatively smaller absolute *levels* of income gains
  - But relatively larger *percentage* increases of total income

	2026-2030		2041-2045	
Household (HH) Income Bracket	Amount (mil of $)	Percent Change	Amount (mil of $)	Percent Change
HH1 < $10,000	1.1	0.16%	2.7	0.38%
$10,000 < HH2 < $25,000	2.1	0.09%	7.2	0.32%
$25,000 < HH3 < $30,000	4.0	0.12%	11.4	0.35%
$30,000 < HH4 < $40,000	6.2	0.14%	16.8	0.39%
$40,000 < HH5 < $60,000	12.8	0.13%	35.5	0.37%
$60,000 < HH6 < $80,000	13.8	0.08%	32.9	0.19%
$80,000 < HH7 < $125,000	15.1	0.07%	42.0	0.20%
$125,000 < HH8 < $150,000	30.6	0.14%	64.6	0.30%
$150,000 < HH9	31.5	0.06%	68.5	0.13%

Income Distribution Impacts Early & No Biofuels–High Example

- Downward signs indicate aggregate income losses compared to SB100–Moderate scenario; upward signs indicate income gains
- In 2026-2030, lower-income households more adversely impacted
- In 2041-2045, more income gains distributed to higher-income households; lowest-income households estimated to have losses

	2026-2030		2041-2045	
Household (HH) Income Bracket	Amount (mil of $)	Percent Change	Amount (mil of $)	Percent Change
HH1 < $10,000	-1.0	-0.14%	-0.4	-0.05%
$10,000 < HH2 < $25,000	-6.6	-0.29%	-0.5	-0.02%
$25,000 < HH3 < $30,000	-11.8	-0.36%	0.3	0.01%
$30,000 < HH4 < $40,000	-15.9	-0.37%	0.3	0.01%
$40,000 < HH5 < $60,000	-33.4	-0.35%	0.6	0.01%
$60,000 < HH6 < $80,000	-36.2	-0.21%	5.5	0.03%
$80,000 < HH7 < $125,000	-42.4	-0.20%	4.1	0.02%
$125,000 < HH8 < $150,000	-43.7	-0.20%	5.5	0.03%
$150,000 < HH9	-82.4	-0.15%	36.5	0.07%

Income Inequality: Gini Coefficients

- For some scenarios, results are less easy to interpret
- Gini coefficient is a better way of determining welfare effects than looking at changes in household income levels
- Gini coefficient is a one-parameter estimate of income inequality (between 0 and 1; higher values indicating higher income inequality)
- Baseline Gini coefficient for Los Angeles: 0.4582
- Changes in Gini coefficients, i.e., inequality, are very small (ranging between 0.05% and 0.25%)

Income Inequality: Gini Coefficients

- All scenarios contribute towards greater income inequality in absolute terms but when compared with SB100–Moderate there are increases and decreases
- Scenarios that project increased earnings relative to the SB100–Moderate scenario result in a more equal income distribution
- Scenarios that project decreased earnings relative to SB100–Moderate scenario increase income inequality
- However, **all impacts remain small in absolute and relative terms**

Macroeconomic Impacts of CAPs

Studies	Base Case(s) GRP Impact in Target Year	Base Case(s) Employment Impact in Target Year	Range of Employment Impacts / Sensitivity Factors	Citation
Wisconsin Public Service Commission; Stationary + Mobile Sources (2011-25)	0.62%	0.56%	n.a.	Miller et al. (2010)
New Mexico Environmental Improvement Board; C&T + Complementary Policies (2010-20)	0.26% to 0.22%	-0.56% to 0.22%	Sensitivity of CAP components: Inclusion of C&T, Allowance Price and Stringency of Complementary Policies	Rose et al. (2010)
Pennsylvania Department of Environmental Protection; Stationary + Mobile Sources (2009-20)	0.31%	0.52%	n.a.	Rose et al. (2011)
New York Energy Research & Development Authority; Stationary + Mobile Sources (2011-30)	0.31%	0.56%	Sensitivity of entire CAP: Base Case: 0.56% Higher Fuel Price: 0.95%	Wei and Rose (2011)
Florida Governor's Office; Stationary + Mobile Sources (2008-25)	0.87%	1.13%	Sensitivity of RPS: Base Case: 0.28% Capital Cost: 0.27% to 0.29%; Price of Replaced Electricity: 0.17% to 0.40%	Rose and Wei (2012)
California (Next 10); C&T + Complementary Policies (2020-45)	0.2% to 0.5%	0.4% to 0.6%	Sensitivity of CAP Components: Allowance Price Pass-thru & Revenue Recycling	Rose et al. (2012)
Southern California Association of Governments; Stationary Sources (2013-35)	-0.06%	0.49%	Sensitivity of RPS: Base Case: -0.15% Capital Cost: -0.30% to 0.00%; RPC: -0.151% to -0.148% NG Price: -0.20% to -0.11%	Wei and Rose (2014)
Southern California Association of Governments; Transportation & Land Use (2013-35)	0.17%	0.19%	n.a.	Lawrence et al. (2016)
Baja California (Border Environment Cooperation Commission); Stationary + Mobile Sources (2015-30)	2030: -0.02%	2030: 0.08%	Sensitivity of Energy Supply Diversification: Base Case: -0.183% RPC: -0.188% to -0.177% Capital Cost: -0.339% to -0.025% NG Fuel Cost: -0.245% to -0.133%	Wei et al. (2017)
City of LA (LADWP/NREL); 100% Renewable Electricity (2026-45)	-0.63% to 0.54%	-0.21% to 0.34%	Sensitivity to Future Electricity Prices -0.79% to -0.06%	Keyser et al. (2021)

Conclusion

- Climate Action Plan primary goal of reducing GHGs has great potential, especially in California
- Creating new jobs is a worthy co-benefit:
  - Employment gains are typically projected as positive
  - However, these are typically less than a 1% change over baseline
  - Thus, CAPs are neither a panacea nor a job killer
- Key factors affecting job impacts:
  - capital cost of mitigation technology
  - net cost saving potential
  - projection of fuel cost
  - presence/absence of fossil fuel industry
  - in-state/out-of-state sources of funding
- Income inequality impacts can go either way, but are small
- Major factors affecting distribution: elec prices, revenue recycling

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