Economic Impacts of Cargo Handling Equipment Electrification at POLA/POLB

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Outline of the presentation

- Background of the study
- POLA/POLB cargo handling equipment (CHE) electrification impact case study
- Direct costs of transitioning to zero-emission (ZE) CHE
- General description of the REMI Model
- Linkages between direct economic impacts and REMI Model inputs
- Macroeconomic impact results of the base case scenario
- Sensitivity analyses
- Conclusion

Background of the study

- Part of the project to track economic competitiveness of the freight transport sector under the implementation of the California Sustainable Freight Action Plan (CSFAP)
- Working with GO-Biz and the Economic Competitiveness Working Group, we identified electrification of CHE as the focus of this study
- CARB is planning new regulations to become effective in 2026
- ZE CHE is one of the major strategies in POLA/POLB Clean Air Action Plan
  - CHE is one of the major pollution sources identified by CAAP
  - CAAP 2030 goal of a zero-emissions fleet

Overview of CHE electrification case study

- Estimate economic impacts of electrifying cargo handling equipment at POLA/POLB
  - Types of CHE included: yard tractors, RTG cranes, top handlers, side picks, forklifts
- Compare costs of equipment, infrastructure, fuel, and O&M expenditures relative to baseline operation and turnover of conventional CHE
- Study period: 2020 to 2045

Yard Tractor

RTG Crane

Side Pick

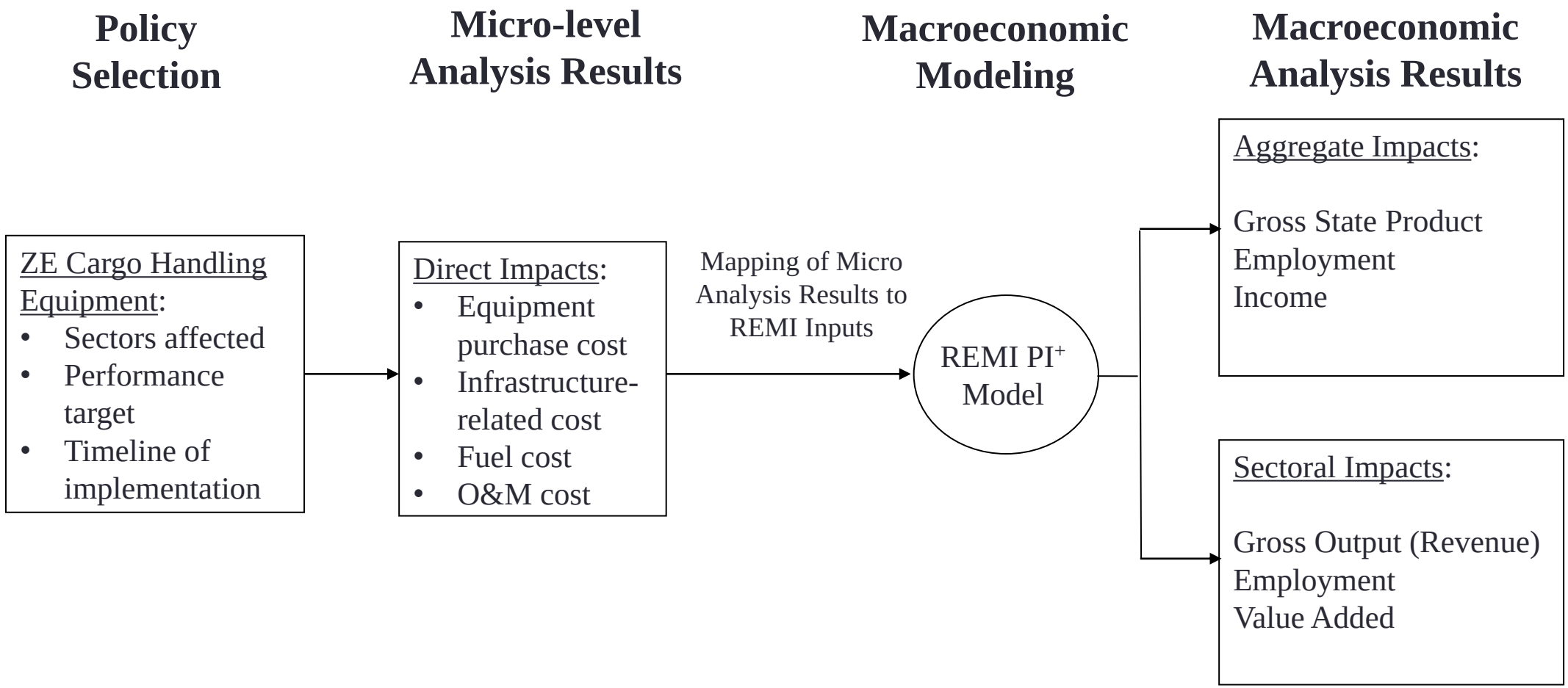
Top Handler

Forklift

What is not included (at this time)

- Automation
  - Port operations do not change other than shift to electric equipment
- Electric power capacity
  - Any upgrades to grid, transmission capacity not included
  - Adequate electricity resources assumed
- Resilience
  - Power interruptions and consequences, preparation, backup systems not included

Our model approach: economic impact analysis



Two main sets of results

Direct impacts

- Capital costs
- Operating costs
- Maintenance costs
- Energy costs

Macro-economic impacts

- Impacts on state economy
- Impacts on industry sectors

Categories of direct costs/savings quantified

- Capital investment costs
  - Battery-electric or grid-electric equipment procurement
  - Battery replacement cost
  - Charger cost
  - Electrical infrastructure cost
  - Civil infrastructure cost
- Operational expenditures
  - Operation and maintenance cost
  - Energy cost

Major assumptions

Capital costs

- Electric equipment price constant $2018
- About 1/3 of equipment purchased from in-state manufacturers
- Electric equipment has same useful life as conventional
- 2:1 replacement in first cycle, 1:1 after
- Chargers serve 2 useful lives of CHE
- One battery replacement per useful life
- Battery cost = 2/3 equipment cost

Op & maint costs

- Per unit operation cost of electric equipment same as conventional CHE
- Maintenance cost is 25% to 30% lower for electric equipment

Energy costs

- Use average of regular and peak demand rates for electricity

Who pays

- State incentive program covers 10% of equipment and infrastructure capital costs
- Remaining costs borne by port operators
- Model assumes costs passed on to customers through higher prices for port services

Summary of results

- Note:
  - All results are relative to business-as-usual baseline; these are incremental costs or savings
  - Costs/saving presented in simple total 2018 $, and in Net Present Value (NPV)
  - Macro-economic impacts measured in four ways:
    - Job-years gained or lost
    - Change in Gross State Product
    - Change in State output
    - Change in personal income

Direct costs/savings of transition to electric CHE

Summary of Total Incremental Costs of Transition to ZE CHE at POLA/POLB (2020-2045)

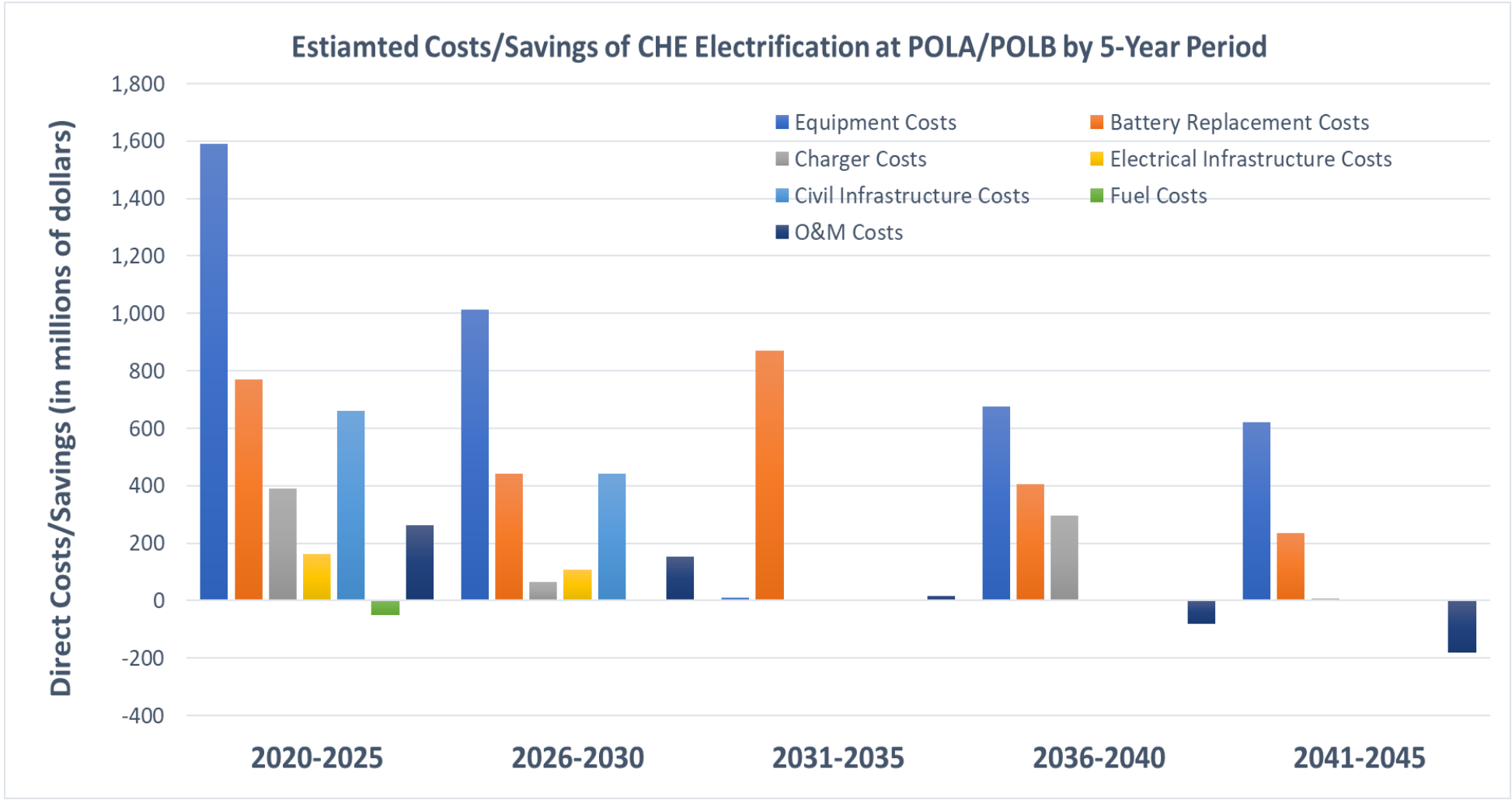
	Simple Total (M $)	NPV (M $)
ZE CHE Equipment Replacement Costs	3,910	3,029
Battery Replacement Costs	2,722	1,886
ZE CHE Charger Costs	755	606
Electrical Charging Infrastructure Upgrade Costs	269	229
Civil Infrastructure Costs	1,102	940
Changes in Fuel Costs of Transition to ZE CHE	-35	-36
Changes in Maintenance Costs of Transition to ZE CHE	169	232
Total	**8,893**	**6,886**

Equipment and battery costs account for 70% of total

Energy cost net savings of $35 million

Total incremental costs about $6.9B in NPV

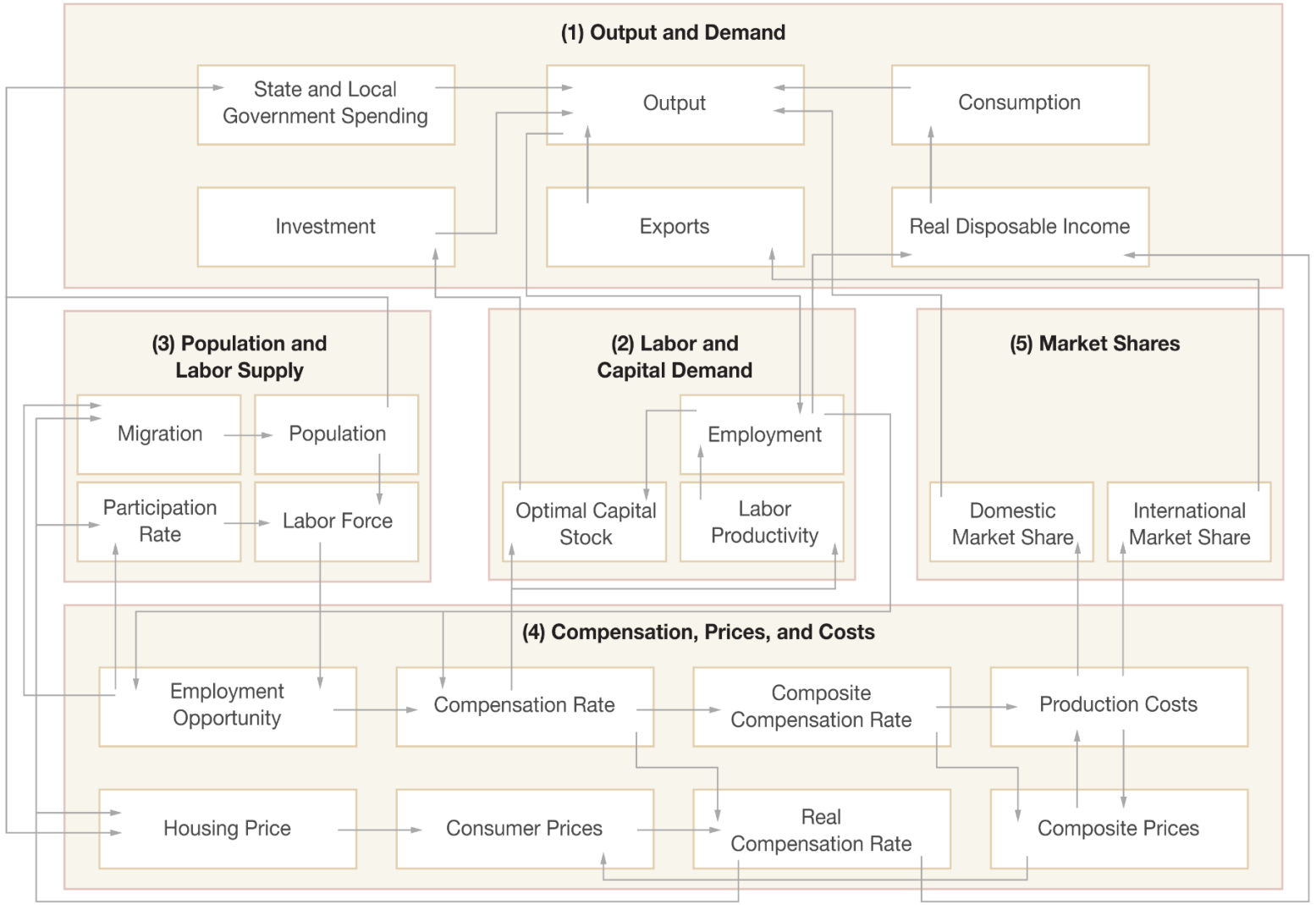
Direct costs/savings change over time



General description of the REMI Model

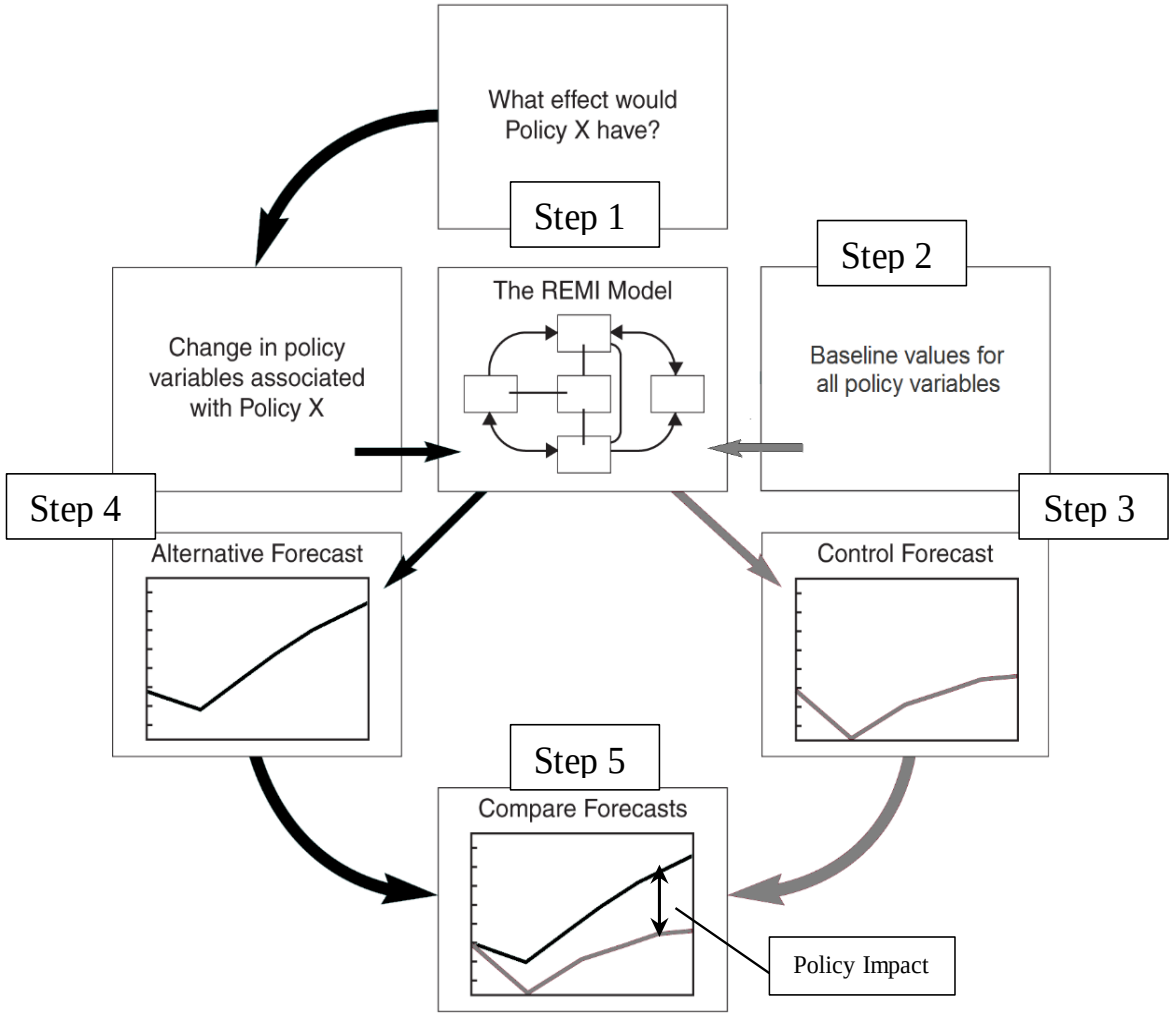
- Regional Economic Models, Inc. (REMI) has evolved over the course of 30 years of refinement.
- One of the most widely used state level and national level macroeconomic modeling tools in the U.S.
- Used to analyze economic impacts in a wide range of topic areas.
- Sectoring scheme: 160 sectors
  - 75 manufacturing sectors
  - 6 energy sectors
  - 8 transportation sectors
  - 59 commercial and services sectors
  - 12 other sectors

REMI model structure



Policy simulation in REMI

1. Policy question formulation.
2. Identification of relevant external policy variables.
3. Baseline, or Control, Forecast establishment
4. Generation of Alternative Policy Forecast
5. Measurement of policy impacts



Linkages between direct impacts and REMI model inputs

	Micro-level Impact Results	Policy Variable Selection in REMI
Positive Stimuli	Increase Spending on CHE Equipment	Output and Demand Block → Final Demand for Other General Purpose Machinery Mfg sector → Increase
	Increase Spending on Battery	Output and Demand Block → Final Demand for Other Electrical Equipment and Component Mfg sector → Increase
	Increase Spending on Charger	Output and Demand Block → Final Demand for products from multiple sectors → Increase
	Electric Charging Infrastructure Investment	Output and Demand Block → Final Demand for Electric Power Generation, Transmission and Distribution; Construction; Electrical Equipment Mfg; Other Electrical Equipment and Component Mfg; Motor Vehicle Mfg sectors → Increase
	Civil Infrastructure Investment	Output and Demand Block → Final Demand for Construction; Cement and Concrete Product Mfg; Architectural and Structural Metals Mfg; Electrical Equipment Mfg; Other Electrical Equipment and Component Mfg sectors → Increase
	Fuel Cost Savings	Compensation, Prices, and Costs Block →Production Cost of Support Activities for Transportation sector →Decrease
	Increase Demand of Electricity	Output and Demand Block →Exogenous Final Demand (amount) for Electric Power Generation, Transmission and Distribution sector → Increase
Negative Stimuli	Increased Maintenance Cost of CHE	Compensation, Prices, and Costs Block →Production Cost of Support Activities for Transportation sector → Increase
	Increased Capital Cost of the Ports	Compensation, Prices, and Costs Block → Capital Cost of Support Activities for Transportation sector → Increase
	Decreased Demand of Diesel	Output and Demand Block → Final Demand for Petroleum & Coal Products Mfg sector → Decrease

Macro-economic results 1

Total incremental impacts, 2020 - 2045

Variable	Units	NPV (or Total Job-years)
Differences from Baseline Level		
Total Employment	Job-years	-96,771
Gross State Product	B 2018$	-7.24
Output	B 2018$	-13.00
Personal Income	B 2018$	-8.78

There are net losses of jobs and economic output

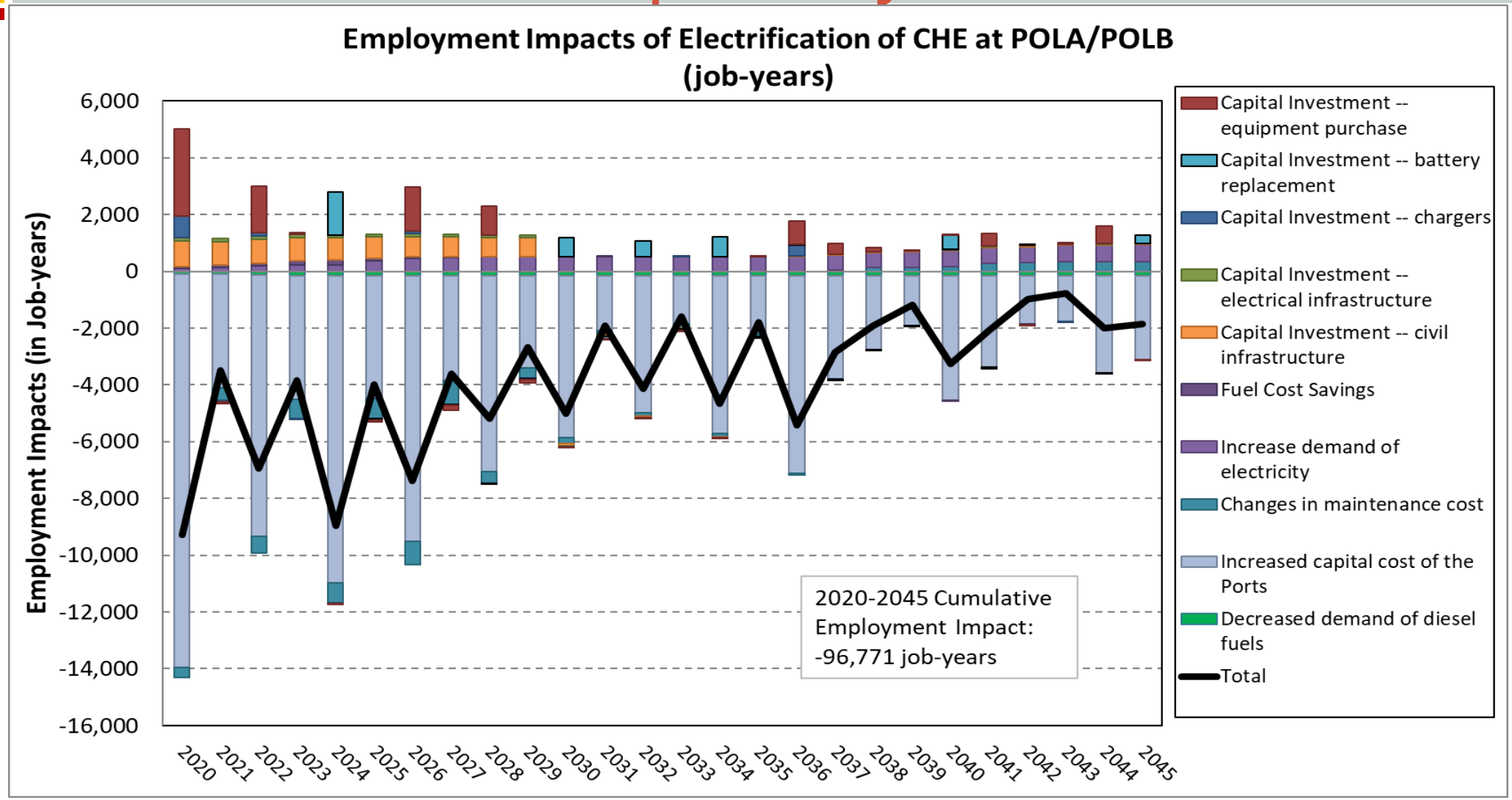
Macro-economic results 2

Variable	Units	Annual Average				
		2020-2025	2026-2030	2031-2035	2036-2040	2041-2045
Differences from Baseline Level						
Total Employment	Job-years	-6,081	-4,767	-2,819	-2,930	-1,540
Gross State Product	B 2018$	-0.57	-0.47	-0.30	-0.32	-0.16
Output	B 2018$	-0.99	-0.85	-0.57	-0.59	-0.33
Personal Income	B 2018$	-0.65	-0.56	-0.36	-0.42	-0.27
Percent Change from Baseline Level						
Total Employment		-0.024%	-0.019%	-0.011%	-0.011%	-0.006%
GSP		-0.019%	-0.014%	-0.008%	-0.008%	-0.004%
Output		-0.019%	-0.015%	-0.010%	-0.009%	-0.005%
Personal Income		-0.025%	-0.020%	-0.011%	-0.012%	-0.007%

Impacts vary over time, with greatest losses in earlier periods.

Impacts are small in percentage terms because of the size of State economy ($3.1T GSP & over 18 million employment in 2019)

Macro-economic impacts by source



Sectoral impacts – top negative impacted sectors

Average Annual Employment Impacts (job-years)

Sector	2020-2025	2026-2030	2031-2035	2036-2040	2041-2045	Average 2020-2045
Support activities for transportation and sightseeing transportation	-887	-1006	-670	-607	-380	**-717**
Wholesale and retail trade	-940	-642	-325	-349	-171	**-503**
Other Transportation	-770	-653	-348	-373	-193	**-479**
Other services	-825	-590	-268	-326	-156	**-448**
Professional, scientific, and business services	-681	-528	-309	-303	-141	**-403**

Sectoral impacts – top positively impacted sectors

Average Annual Employment Impacts (job-years)

Sector	2020-2025	2026-2030	2031-2035	2036-2040	2041-2045	Average (2020-2045)
Other general purpose machinery manufacturing	204	129	1	64	51	**94**
Utilities	6	35	42	46	52	**35**
Electrical equipment manufacturing	16	11	0	0	0	**6**

Transportation sector impacts – CA vs. Rest of U.S.

NPV of Gross Output Impacts – CA vs. Rest of U.S., billions 2018$

	Support Activities for Transportation Sector		Aggregate Transportation Sector	
	CA	Rest of U.S.	CA	Rest of U.S.
Base case	-2.65	2.06	-3.95	1.95

- Gross output in the port-related sector and aggregate transportation sector in CA decreases, while gross output in these sectors in rest of U.S. increases.
- Some port related business is shifted out of California and to other states
- Amount is small relative to state economy

Sensitivity cases on funding sources

- Base case: state incentive programs cover 10% of equipment and infrastructure costs; rest of costs borne by ports and passed onto downstream customers
- Sensitivity Case 1: no state incentive funding; 100% costs borne by ports
- Sensitivity Case 2: the 10% government subsidy is offset by reductions in other government spending
- Sensitivity Case 3: the 10% government subsidy is funded through an increase in gasoline tax
- Sensitivity Case 4: ports can only partially pass increased costs onto downstream customers

Sensitivity simulation results on funding sources

Scenarios	Total Employment Impact (job-years)	GSP Impact (NPV in B $)	Output Impact (NPV in B $)
Base case	-96,771	-7.24	-13.00
Sensitivity Case 1	-105,565	-7.96	-14.30
Sensitivity Case 2	-99,757	-7.55	-13.55
Sensitivity Case 3	-102,746	-7.87	-14.14
Sensitivity Case 4	-86,583	-6.41	-11.75

- Various incentive programs help improvement economic performance
- However, if providing incentives need to be offset by reducing gov't spending in other areas or increasing gas tax, the improvement in economic performance will be reduced
- If ports only pass partial cost onto downstream customers, macroeconomic impacts improve because of the reduced negative supply-chain (or multiplier) effects

Sensitivity analysis – lower- and upper-bound cost cases

Assumptions on key parameters

Variable	Lower-bound	Upper-bound
CHE equipment cost	10% lower than base case	10% higher than base case
Battery cost	10% lower than base case	10% higher than base case
Charger cost	10% lower than base case	10% higher than base case
Infrastructure cost	20% lower than base case	20% higher than base case
Replacement ratio between electric and diesel CHE	1:1 ratio for any replacement after 2025	1:1 ratio for any replacement after 2035
Cost of electricity	SCE EV rate until 2024; electricity rate with lower demand charge (60% of total electricity cost) after 2024	Electricity rate with higher demand charge (85% of total electricity cost) for the entire study period

Total Incremental Costs (NPV) of Transition to ZE CHE

(in millions of dollars)

	Base Case	Lower-Bound	Upper-Bound
Equipment Replacement Costs	3,029	2,320	3,952
Battery Replacement Costs	1,886	1,548	2,368
Charger Costs	606	545	666
Electrical Infrastructure Upgrade Costs	229	184	275
Civil Infrastructure Costs	940	752	1,128
Changes in Fuel Costs	-36	-300	257
Changes in Maintenance Costs	232	-35	571
Total	**6,886**	**5,013**	**9,218**

Total Economic Impacts of Lower-Bound and Upper-Bound Cost Sensitivity Cases

(in millions of dollars)

Scenarios	Employment Impact (job-years)	GSP Impact (NPV in B $)	Output Impact (NPV in B $)
Base Case	-96,771	-7.24	-13.00
Lower-bound Cost Case	-67,758	-5.19	-9.41
Upper-bound Cost Case	-133,254	-9.76	-17.41

Conclusions

- Incremental costs of electronification of CHE at POLA/POLB between 2020 and 2045 are estimated to be between $5 billion and $9.2 billion in NPV.
  - Equipment purchase and battery replacement costs account for more than 70% of the total incremental costs.
  - The greatest incremental costs will incur in earlier periods.
- Total employment impacts are estimated to be between 68 to 133 thousand job-years losses between 2020 and 2045
  - The impacts remain small in percentage terms because of the size of the state economy
  - Port sector, other transportation, wholesale trade and retail trade are the top negatively impacted sectors
  - Increased capital cost of the port sector results in the highest negative impacts on the economy
  - Some port related business can be shifted out of California and to other states

Conclusions

- Sensitivity analyses identify key factors that affect incremental costs of CHE electrification and macroeconomic impacts of this transition
  - Development of battery technology
  - Government incentive programs
  - Electricity costs
- Increased load for fully electrified ports may only account for a small portion of total peak load in SCE and LADWP territories, future studies are needed to evaluate the implications to local transmission and distribution capacities
- Comprehensive impacts evaluation should juxtapose economic impacts of this policy along with environmental and other co-benefits of the regulation