Modeling GHG Emission Reduction Policies in Support of AB32 Using ENERGY 2020

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Outline of Presentation

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3. What's Changed?

4. Reference Projection

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6. Policy Modeling Results

Project Overview

➢ Goal:

    ➢ *Provide the ARB with the modeling capability to analyze policy options for reducing greenhouse gas emissions across all sectors of the California economy. This capability is required for the ARB to fulfill its legislative mandate under AB 32, which requires that the ARB implement a program that reduces the State's GHG emissions to 1990 levels by 2020.*

➢ Key Tasks

    ➢ Update Reference Case to reflect recent economic downturn

    ➢ Incorporate current/approved Model policies specified by the ARB

    ➢ Model impacts of key Complementary Policies and potential Cap-and-Trade configurations
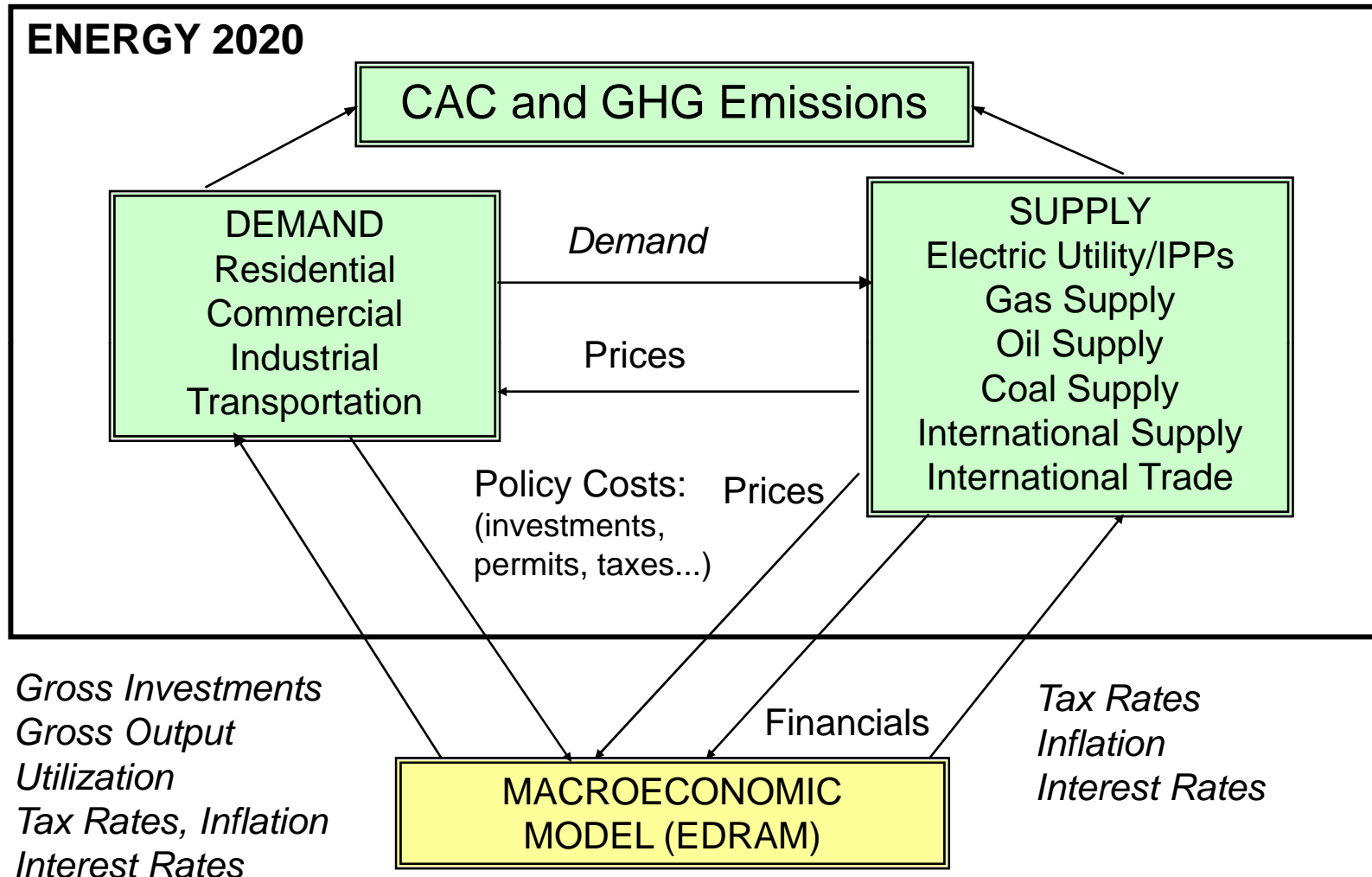
    ➢ Model Sensitivity Cases

ENERGY 2020
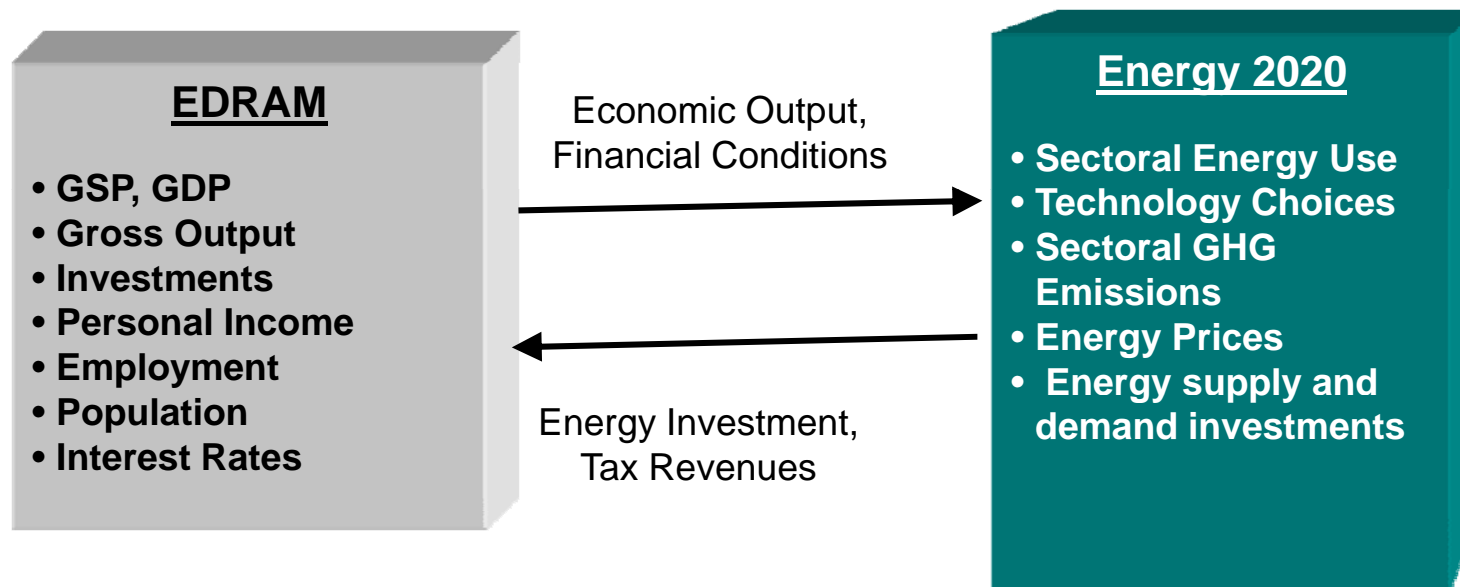# Model Overview and Data Sources

Overview of ENERGY 2020

➢ Integrated model of North American economy, energy and emissions, which includes:

    ➢ All U.S. States and Canadian Provinces (model for California limited to WECC jurisdictions).

    ➢ Disaggregated energy demand by end-use by sector.

    ➢ Energy supply for electricity, oil, gas, coal, and renewables.

➢ Models each type of air emission:

    ➢ Greenhouse Gas (CO_2, N_2O, CH_4, SF_6, HFC, PFC)

Model Structure & Relationships

Information Exchange between Models

EDRAM

- GSP, GDP
- Gross Output
- Investments
- Personal Income
- Employment
- Population
- Interest Rates

Economic Output, Financial Conditions →

← Energy Investment, Tax Revenues

Energy 2020

- **Sectoral Energy Use**
- **Technology Choices**
- **Sectoral GHG Emissions**
- **Energy Prices**
- **Energy supply and demand investments**

Modeling Principles

➤ Key Decisions are Endogenous

➤ Based on Stocks and Flows

➤ Simulates decisions at the margin (not average)

➤ Causality vs. Correlation

➤ Actual vs. Optimal Decisions

➤ Dynamically describes the behavior of both energy
suppliers and consumers for all fuels and for all end-uses

Experience with ENERGY 2020

- Over 30 years of experience analyzing energy policy.
- Model has been used to simulate impacts of electric system deregulation, model Integrated Resource Plans (IRP's), and model energy and climate plans.
- Climate change policies modeled for several US states and Canadian provinces and Environment Canada.
- Currently being applied to model the impacts of the cap-and-trade program proposed by the Western Climate Initiative (WCI).
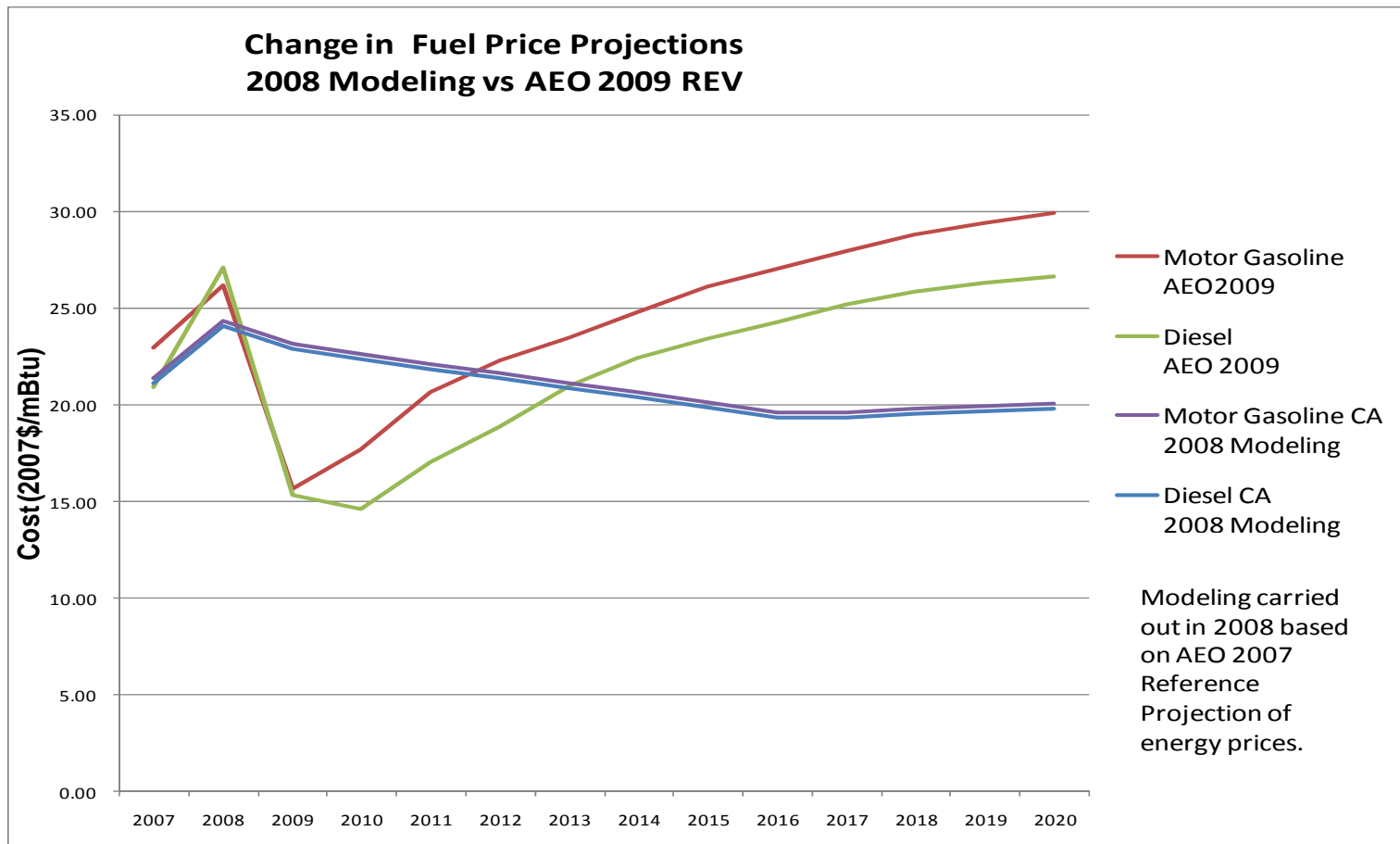
Sources for Key Inputs

Input Category	Data for California	Data for Other West
Population and Macroeconomic Data	California State Sources	Census EIA, BEA
Fuel Prices	CA state sources E3 for electric sector EIA for other	EIA
Energy Use and Consumption	CEC/ARB GHG Inventory	EIA State Energy Consumption, Price, and Expenditure Estimates (SEDS)
Emissions	CEC/ARB GHG Inventory	EPA
Electricity Generation Capacity and Operational Data	FERC and NERC CPUC GHG Modeling process	

What's Changed?

Review of Model Updates

➢ Updated macroeconomic forecast to include economic downturn.

➢ Updated energy price forecast to use more recent AEO 2009 projection *(see next slide).*

➢ Review of planned and committed power plants, complementary policies modeling assumptions and power imports.

➢ Added RPS requirements for each US state and renewable targets for Canadian provinces.

Updated Energy Price Forecast (AEO 2009)

Change in Fuel Price Projections
2008 Modeling vs AEO 2009 REV

Y-axis: Cost (2007$/mBtu), from 0.00 to 35.00

X-axis: 2007 through 2020

Legend:
- Motor Gasoline AEO2009
- Diesel AEO 2009
- Motor Gasoline CA 2008 Modeling
- Diesel CA 2008 Modeling

Modeling carried out in 2008 based on AEO 2007 Reference Projection of energy prices.

- Projected increase in oil prices is higher than 2007 AEO forecast used in 2008 modeling.

Reference Projection

Reference Projection

Key policies and assumptions included:

- ➤ AEO 2009 Reference Price forecast
- ➤ Economic forecast includes downturn
- ➤ Low Carbon Fuel Standard for California (10% reduction in carbon content by 2020)
- ➤ Pavley Vehicle Standard for California (35.5 mpg by 2016)
- ➤ 2007 EISA requirements for other states
  - ➤ CAFÉ provisions (new vehicles average 35.5 mpg by 2020).
  - ➤ Biofuels mandate
- ➤ RPS:
  - ➤ California - 20% of electricity sales from renewables.
  - ➤ All other jurisdictions meet their State/Provincial targets.

Summary of Reference Case

➢ Economic output and emissions in 2020 lower than in modeling completed last year.

➢ Growth in Gross Output averaged 3.1% growth (2007 to 2020) in prior Reference Case compared to 2.7% in updated 2009 model.

➢ Total emissions for CA approximately 492 Mt CO2e in 2020 (including emissions associated with power imports).

➢ Limited emissions growth (~10 Mt) between 2006 and 2020.

➢ Graphs which follow show pattern of change & emissions by source/sector in new Reference Case.

Reference Case – Secondary Energy

Total Secondary Energy Use
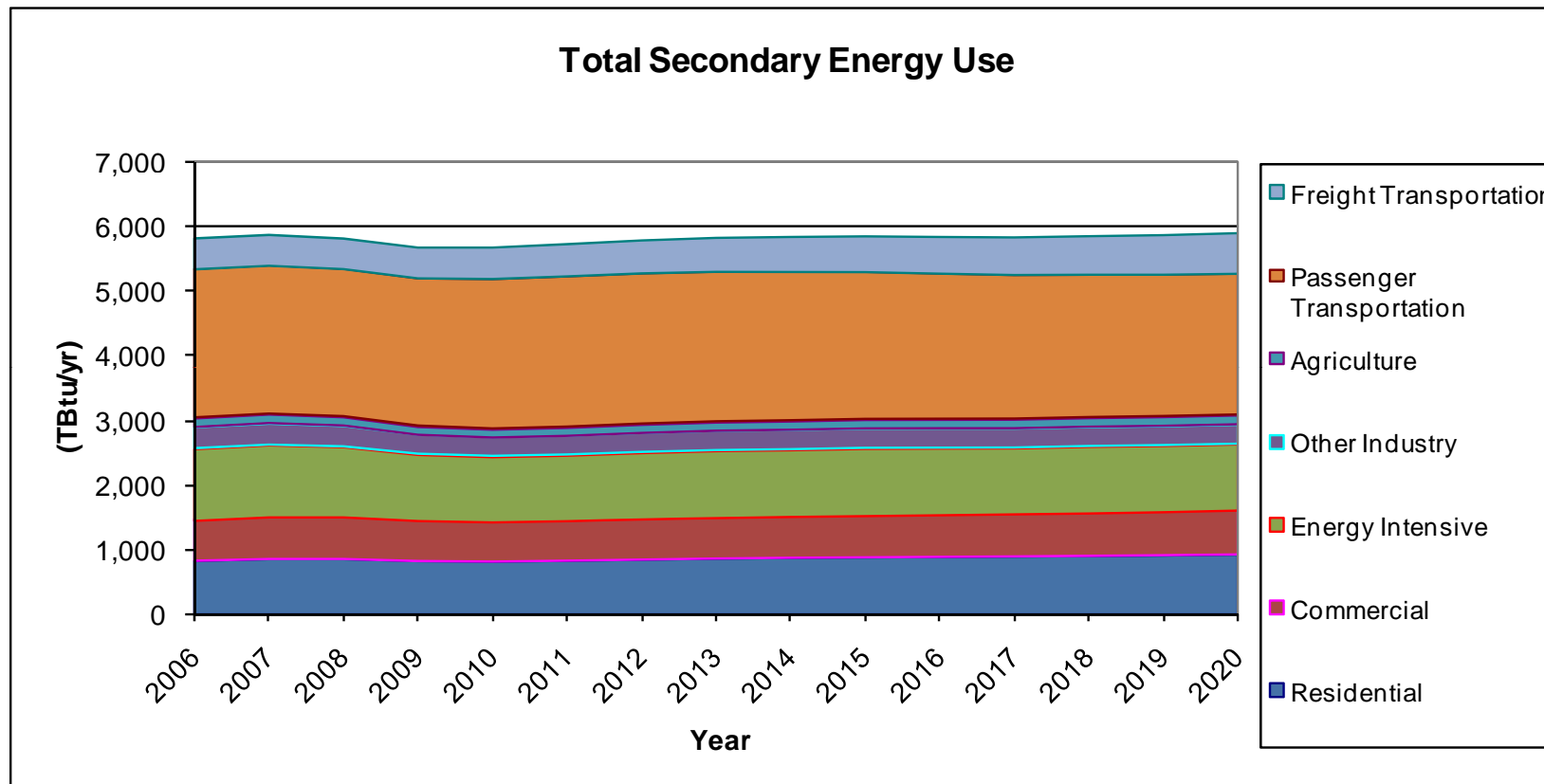
- ➢ Total secondary energy use increases by 0.1% per year to 2020
- ➢ Passenger transportation and industry energy use decline slightly while other sectors see modest growth (all less than 1% except freight).

Reference Case - Electricity

Sales (GWh/year)	2006	2012	2015	2020	Avg. Annual Growth Rate 2006-2020
Residential	85,684	84,905	88,362	93,265	0.6%
Commercial	114,324	107,852	110,728	120,057	0.4%
Industrial	61,523	55,760	55,663	55,506	-0.7%
Transportation	2,613	3,068	3,115	3,162	1.4%
Street/Misc	6,073	6,073	6,073	6,073	0.0%
Resale	-	-	-	-	#N/A
Total	**270,216**	**254,773**	**263,941**	**278,063**	**0.2%**

Electricity Sales By Sector
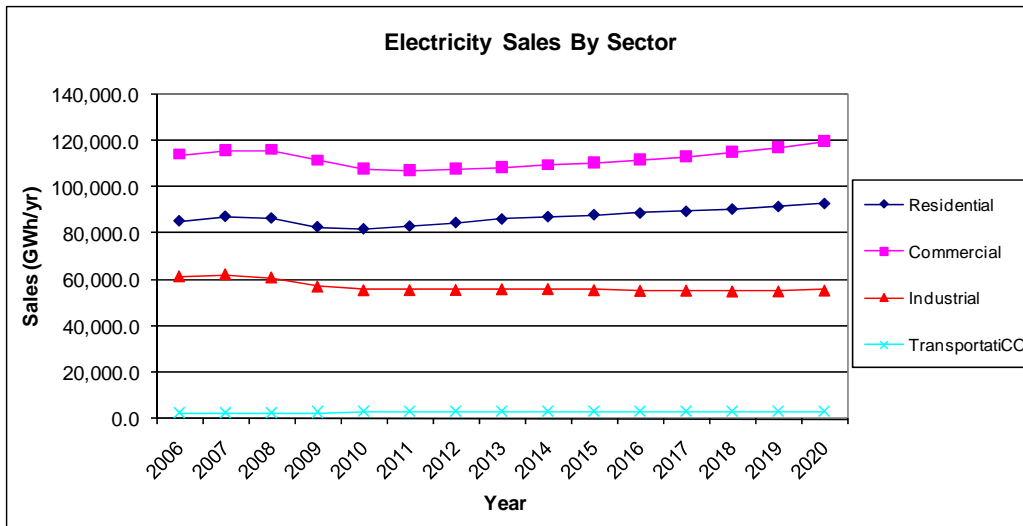
- Electricity sales decline in 2009 to 2011 period then continue growth.
- Total electricity sales increase by average of 0.2% per year to 2020.

Reference Projection – Power Sector

Generation Output (GWh/year)	2006	2012	2015	2020	Avg. Annual Growth Rate 2006-2020
Gas/Oil	83,708	64,498	54,650	50,937	-3.5%
Coal	2,946	2,367	2,341	2,367	-1.6%
Nuclear	31,560	31,560	31,560	31,560	0.0%
Hydro	48,114	48,140	48,199	48,199	0.0%
Biomass	5,674	5,844	6,013	6,312	0.8%
Wind	4,818	5,973	7,101	8,979	4.5%
Other Renewable	13,584	14,855	16,127	18,247	2.1%
Total	**190,405**	**173,238**	**165,990**	**166,601**	**-0.9%**

- ➢ Wind and renewables increase to meet RPS requirements.
- ➢ Fossil generation (gas/oil/coal) decline from about 45% of in-state generation in 2006 to 32% in 2020.
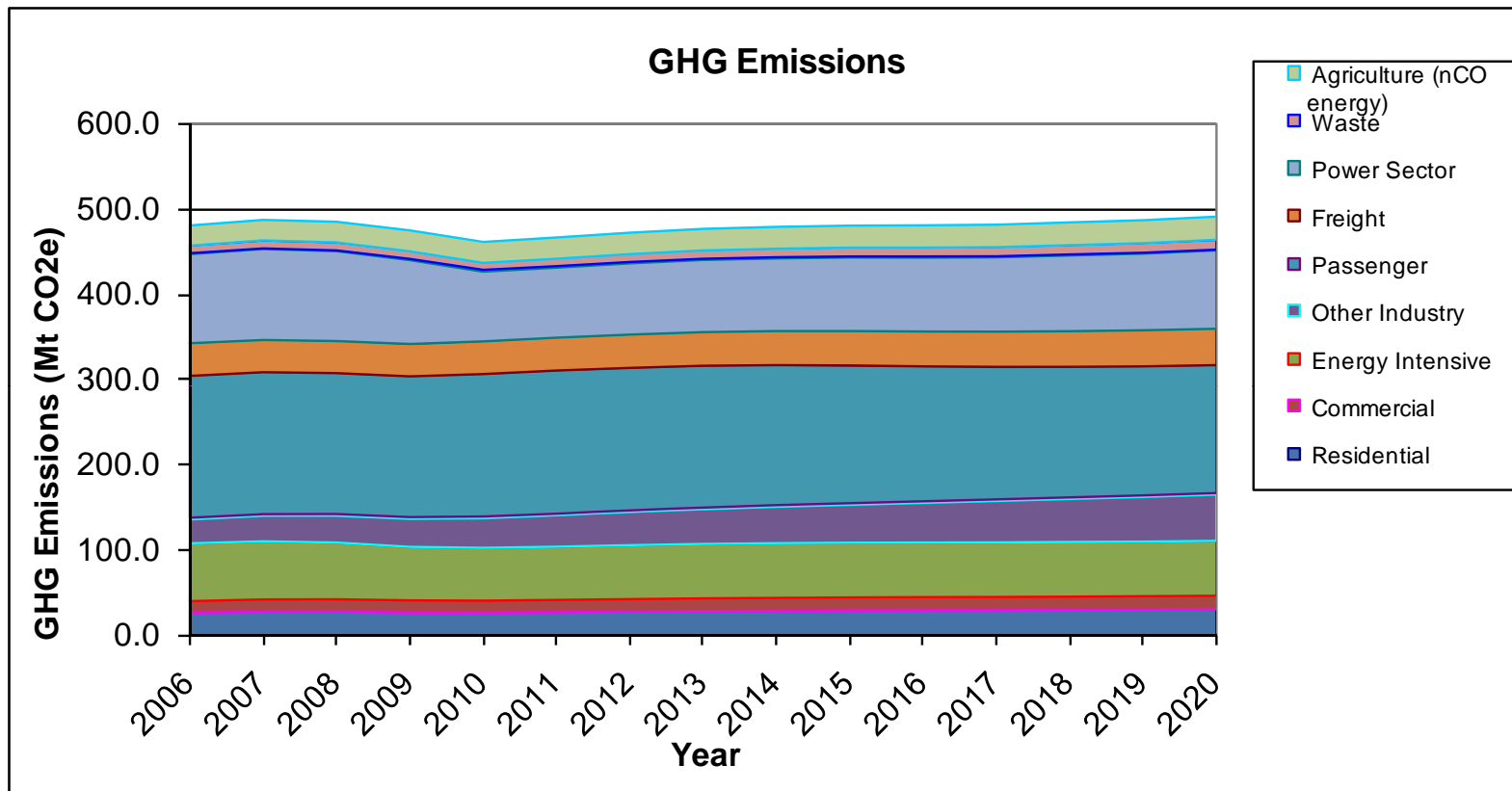- ➢ Imports increase over period from 30% of sales to about 40% by 2020

Reference Projection – Transportation

Marginal Vehicle Efficiency *(miles/gallon)*					
Passenger Vehicles	**2006**	**2012**	**2015**	**2020**	**Avg. Annual Growth Rate 2006-2020**
Light Gasoline	24.2	32.4	38.9	42.6	4.1%
Medium Gasoline	24.2	32.4	38.9	42.6	4.1%
Heavy Gasoline	17.3	21.7	25.1	26.5	3.1%
Heavy Diesel	17.3	21.5	24.8	26.2	3.0%
Fleet Average	21.4	28.6	33.9	36.6	3.9%

Renewable Shares	**2006**	**2012**	**2015**	**2020**	**Difference 2006-2020**
Ethanol/Gasoline	3.8%	8.4%	11.7%	15.0%	11.3%
Biodiesel/Diesel	0.0%	9.5%	19.1%	35.0%	35.0%

➢ New vehicle efficiency increases to meet targets under Pavley (slightly exceeds target of 35.5 mpg by 2020).

➢ Ethanol and biodiesel increase as a share of total fuel to meet LCFS.

➢ Passenger VMT grows by about 2% per year.

➢ Freight VMT rises by 2.7% per year (2006 to 2020).

➢Some shift to larger vehicles as efficiency improvement reduces cost of driving (~1% shift from 2006 to 2020 to larger vehicles).

Reference Projection – GHG Emissions

GHG Emissions

Legend:
- Agriculture (nCO energy)
- Waste
- Power Sector
- Freight
- Passenger
- Other Industry
- Energy Intensive
- Commercial
- Residential

Y-axis: GHG Emissions (Mt CO2e) — 0.0, 100.0, 200.0, 300.0, 400.0, 500.0, 600.0

X-axis (Year): 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020

➢ Emissions increase in all sectors except energy intensive industry, passenger transportation and power sector.
➢ Growth in 'other industry' sector related to non-energy emissions.

Reference Projection – GHG Emissions

GHG Emissions (Mt)	2006	2012	2015	2020	Avg. Annual Growth Rate 2006-2020
Residential	27.9	29.0	30.2	31.6	0.9%
Commercial	14.1	15.3	16.0	16.7	1.3%
Energy Intensive	67.7	63.1	64.1	64.1	-0.4%
Other Industry	27.9	38.7	44.6	54.2	4.9%
Passenger	167.5	168.2	162.1	150.7	-0.8%
Freight	37.9	38.9	40.5	42.8	0.9%
Power Sector Including Imports	105.7	84.5	87.2	92.7	-0.9%
Waste	9.8	10.9	11.5	12.4	1.7%
Agriculture (non energy)	23.6	25.0	25.7	27.0	1.0%
Total	**482.1**	**473.6**	**481.9**	**492.3**	**0.1%**

Note – Power Sector includes emissions associated with imports

➢ Emissions from passenger transportation, energy intensive industry, and power sector decline. Commercial and other industry sectors see emissions increase.

➢Total GHG emissions rise slightly (10 Mt) by 2020; growing on average by 0.1% per year.

Comparison to Other Projections:

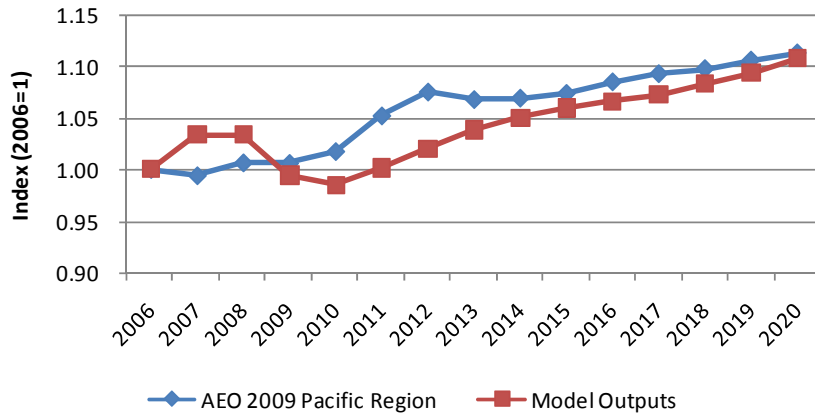**Electricity Demand Projection
Comparison to CEC**
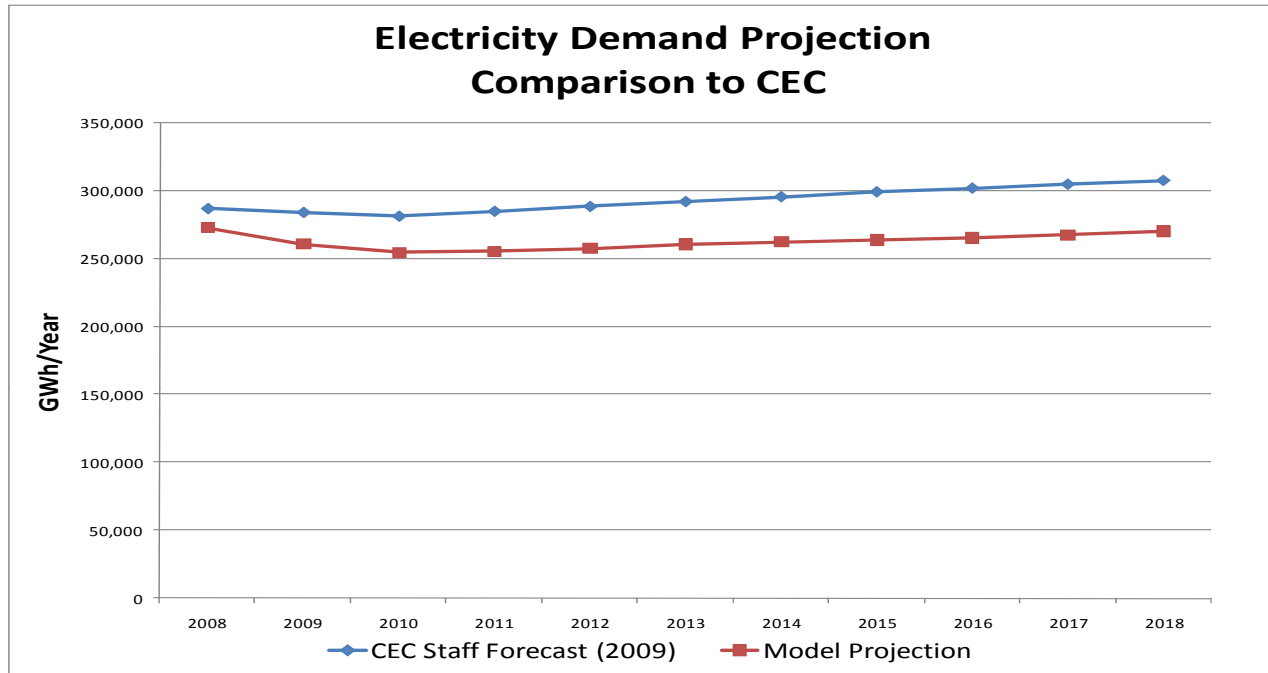
- ➢ Electricity demand projection shows similar growth to latest CEC staff projection, though starting point not aligned.
- ➢ CEC projection of Personal Income used in staff projection shows growth of roughly 21% from 2009 to 2018.
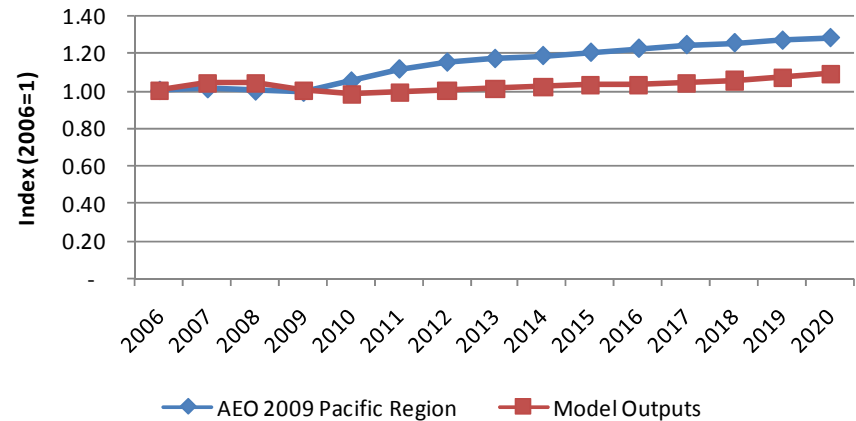- ➢ Projection used for ENERGY 2020 shows similar (26%) growth.

Comparison with Other Projections
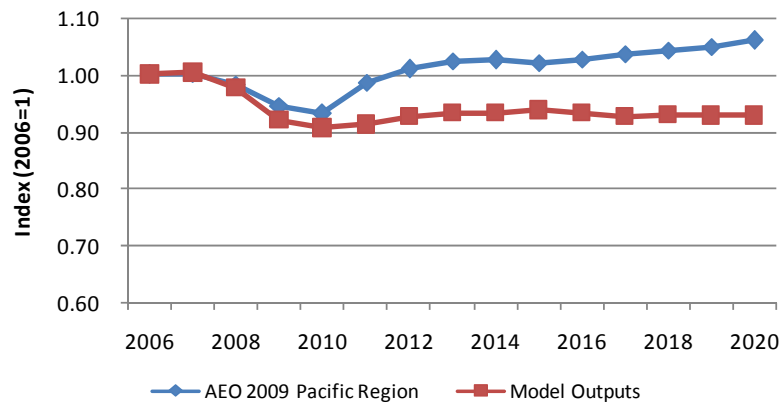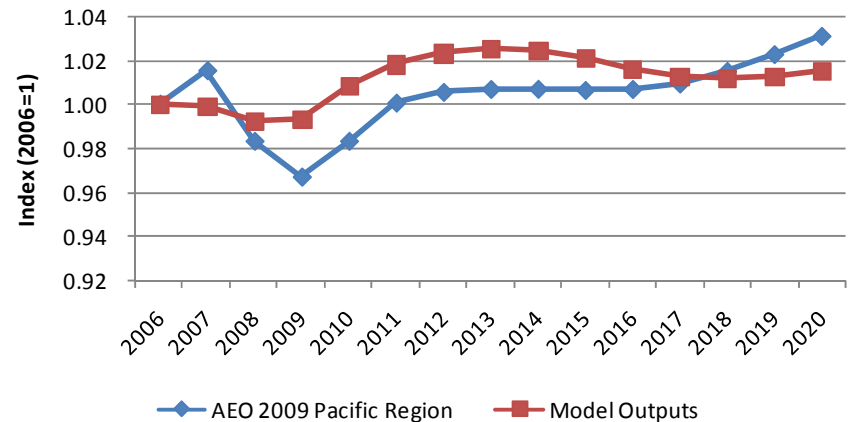## AEO 2009 (Pacific Region – not direct comparison with CA)

Policies Modeled

Complementary Policies Modeled

Policy	Region	Goal
Pavley Vehicle Standards II	California	• 42.5 mpg average new vehicle efficiency by 2020.
Renewable Portfolio Standard (now Renewable Electricity Standard)	California specific increase	• RPS increased from 20% of electricity sales supplied from renewable resources to 33%. • New resource additions based on projected resource mix from CEC.
Energy efficiency	California	• 10% in electricity use in 2020 or about a 1% per year reduction in electricity consumption. • 4% of projected natural gas use in 2020.
Combined Heat and Power	California	• Increase CHP use by 30,000 GWh

Complementary Policies Modeled

Policy	Region	Goal
VMT Reduction Measure	CA Only	VMT decrease of 4% from Reference Case levels by 2020
Other Transportation and Goods Movement Policies	CA Only	Heavy-duty vehicle efficiency and ship use of off-shore power. Total reduction <2 MMT

Policies Modeled – Cap & Trade

- ➤ **Region**
  - ➤ California

- ➤ **Covered GHG Pollutants**
  - ➤ CO_2, CH_4, N_2O, SF_6, PFC, and HFC

- ➤ **2020 Goal**
  - ➤ 14% below 2006 base emissions (Target of 427 MMT in 2020)

- ➤ **Covered Sectors:**
  - ➤ **2012-2014 - Narrow Scope:**
    - ➤ Electricity and Industrials emitting >25,000 tCO2e
  - ➤ **2015-2020 - Broad Scope**
    - ➤ Narrow Scope plus transportation fuels, commercial and residential fuels and small industrial.

- • *Note - Consistent with WCI Phase 3 Main Cap and Trade Case*

Policies Modeled – Cap & Trade

➢ **Banking**

 ➢ Allowed without limitation

➢ **Allowance Allocation** for Electricity generation (two cases)

  ➢ 100% Auction

  ➢ 0% Auction

➢ **Offsets -** Two cases

   (based on 100% auction scenario)

  1. No offsets

  2. Offsets at approximately $20 per tonne for up to 49% of reduction from initial cap levels.

Policies Modeled – Summary

No.	Scenario Name		Allocation (% gratis) reduction)	Offsets (as % of reduction)	Complementary Policies				
					VMT	Pavley II	CHP	EE	RPS
1	S0_CT01	No Auction with offsets	100%	49%	-4%	Y	Y	Y	33%
2	S0_CT02	No Auction/no offsets	100%	0%	-4%	Y	Y	Y	33%
3	S0_CT03	Auction with offsets	0%	49%	-4%	Y	Y	Y	33%
4	S0_CT04	Auction/no offsets	0%	0%	-4%	Y	Y	Y	33%
5	S1_CT01	Lower Transport CP	100%	49%	0%	50%	Y	Y	33%
6	S2_CT01	Less Efficiency	100%	49%	-4%	Y	50%	50%	20%
7	S3_CT01	Less Trans & Efficiency	100%	49%	0%	50%	50%	50%	20%

➤ Modeled four Cap-and-Trade configurations and three sensitivity cases.

Policy Modeling Results

Policy Modeling Results:
C&T 100% Allocation (Gratis)/No Offsets

Change from the Reference Case in 2020:

➢ Secondary energy use declines by over 7%, with all sectors showing a decrease from Reference levels.

➢ Passenger transportation energy use declines by ~6%.

➢ Electricity sales decline by almost 18% due to increases in self-generation and energy efficiency.

➢ In-state generation plus imports meet 33% RPS/RES goal.

➢ Allowance prices rise to $37/tonne by 2020.

➢ GHG emissions fall by about 60 Mt CO2e by 2020, or over 14%, relative to Reference Case.

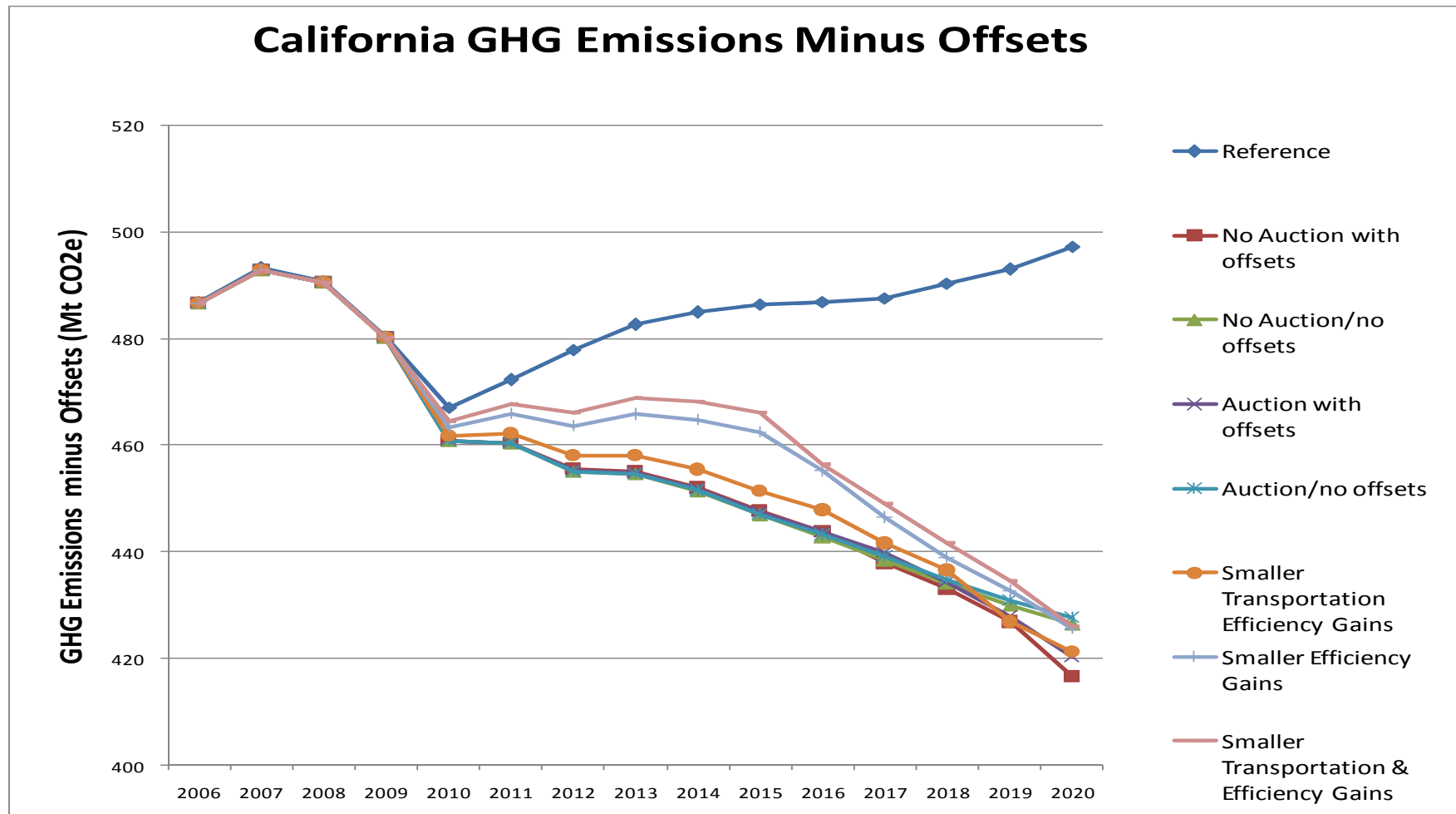# Policy Modeling Results:
C&T 100% Allocation (Gratis)/No Offsets

➢ Electricity prices for rise by about 3%.

➢ Energy prices rise by 20% for natural gas, 14-16% for fuel oil and 9-12% for transportation fuels as carbon costs are added.

➢ Fuel expenditures decline for all sectors as efficiency gains exceed energy price increases.

➢ Average energy expenditures, across all sectors, decline by about 9% in real terms.

Policy Modeling Results:
C&T 100% Allocation (Gratis) with Offsets

Change from the Reference Case in 2020:

➤ Allowance prices rise to $21/tonne by 2020.

➤ Secondary energy use declines by 6.5% (slightly less than in case with no offsets).

➤ Electricity sales decline by almost 19%.

➤ Electricity & fuel price increases lower than in case with no offsets (reflecting lower carbon price).

➤ GHG emissions fall by over 67 Mt CO2e by 2020, or over 13%, relative to Reference Case.

➤ Availability of offsets/lower carbon price results in somewhat lower efficiency gains and GHG emission reductions from capped sources.
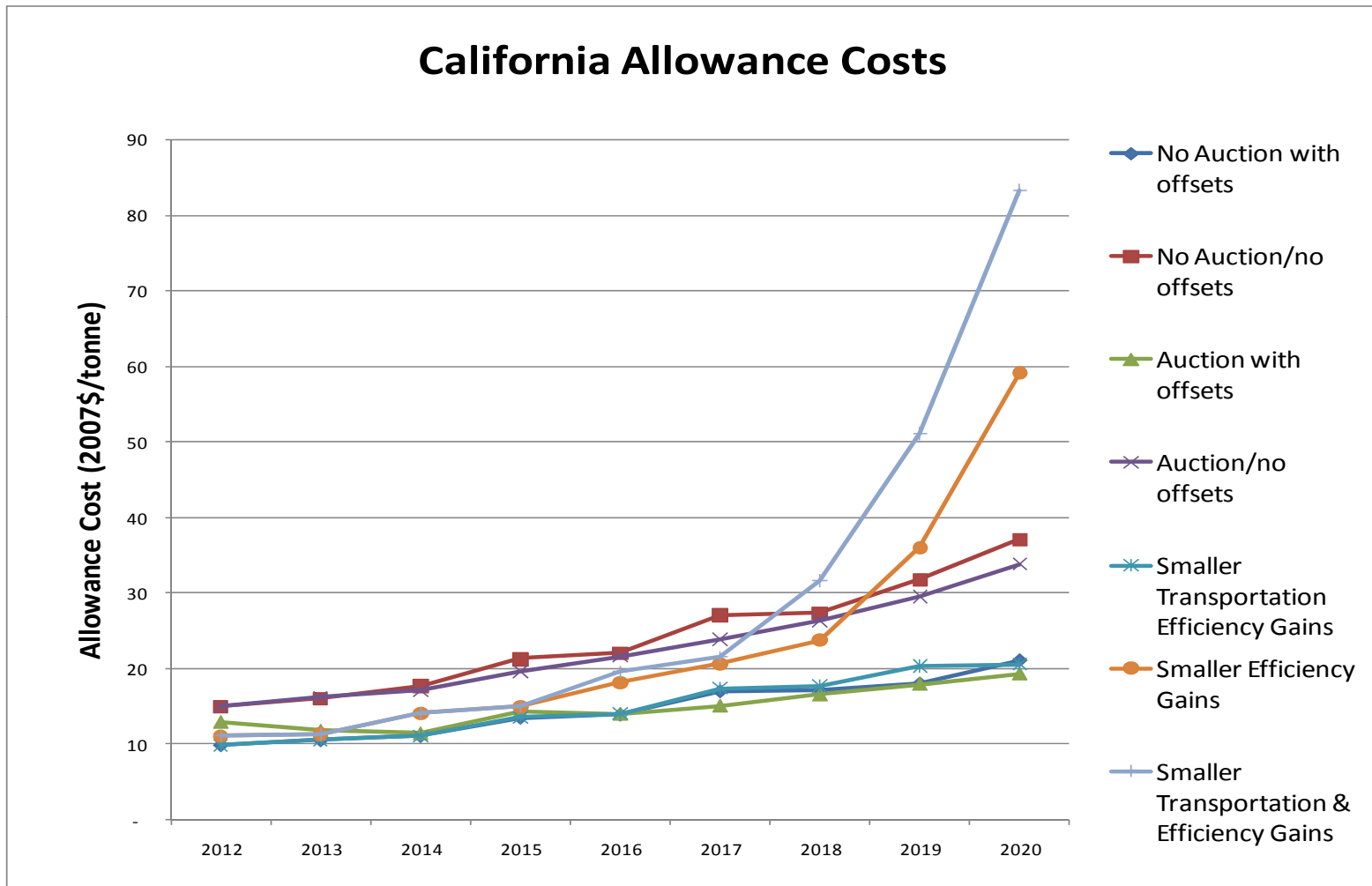
Policy Modeling Results: GHG Emissions

California GHG Emissions Minus Offsets

Policy Modeling Results: Summary

No.	Scenario Results for 2020	GHG Emissions (Mt CO2e)	Change from RC (Mt CO2e)	Offsets Used (Mt CO2e)	Emissions net of Offsets (Mt CO2e)	2020 Bank Inventory (Mt CO2e)	Allowance Price (2007$ /tonne)
1	No Auction with offsets	430	68	13	417	5	$21
2	No Auction/no offsets	426	71	-	426	16	$37
3	Auction with offsets	430	67	10	420	21	$19
4	Auction/no offsets	428	69	-	428	12	$34
5	Smaller Transportation Efficiency Gains	436	61	15	421	19	$20
6	Smaller Efficiency Gains	453	44	27	426	1	$59
7	Smaller Transportation & Efficiency Gains	457	40	31	426	0	$83

➢ GHG emissions minus offsets fall to or below State target in all cases

➢ Allowance prices approximately 80% higher in cases without offsets.

➢ On-going banking results in some inventory at end of period. Generally highest in cases with lower allowance price.

➢ Less effective complementary policies result in higher allowance price, greater offset use, and lower GHG reductions.

Policy Modeling Results: Allowance Prices

Policy Modeling Results: Summary

No.	Scenario Name	Allowance Price (2007 $/Tonne)								
		2012	2013	2014	2015	2016	2017	2018	2019	2020
1	No Auction with offsets	10	11	11	13	14	17	17	18	21
2	No Auction/no offsets	15	16	18	21	22	27	27	32	37
3	Auction with offsets	13	12	11	14	14	15	17	18	19
4	Auction/no offsets	15	16	17	20	22	24	26	29	34
5	Smaller Transportation Efficiency Gains	10	11	11	14	14	17	18	20	20
6	Smaller Efficiency Gains	11	11	14	15	18	21	24	36	59
7	Smaller Transportation & Efficiency Gains	11	11	14	15	20	22	32	51	83

➢ Allowance price approximately doubles over period in scenarios 1-4.

➢ Change in transportation efficiency and VMT have relatively minor impact on allowance price.

➢ Less energy efficiency results in higher allowance price, particularly in 2019 and 2020.

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