CHP Market Assessment

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Presented by:
Ken Darrow
Bruce Hedman
Anne Hampson

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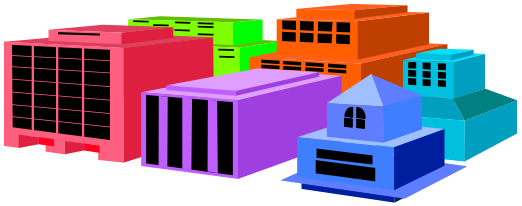
Topics

- Background
- CHP Market Model
- Existing CHP in California
- Target CHP Markets – CHP Technical Potential
- Energy Prices
- CHP Technology
- Base Case Market Forecast
- Alternative Market Cases
- GHG Impacts
- Observations and Conclusions
- Reference Slides – with Glossary

Background – The Current Landscape

- AB-32 is driving current energy policy – ARB *Climate Change Scoping Plan* (12/08) targets 4,000 MW, 30,000 GWh, and 6.7 million metric tons of CO2 emissions reduction from CHP by 2020
- While new growth in CHP is targeted, the future of existing QF contracts for CHP power (representing about 6,000 MW) is in question
- Implementation of AB-1613 is designed to create an economic mechanism for CHP to export power similar to AB-1969 (renewable energy)
- SGIP program canceled for non-fuel cell CHP technology but may be restored by SB-412 Kehoe
- Recession has altered the economic landscape – gas prices are low, economic growth estimates are reduced

ICF CHP Market Model

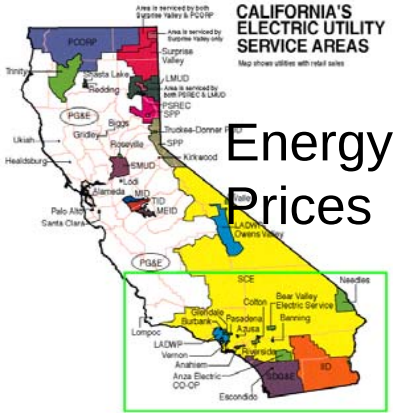


Applications Databases

Output: Technical Market Potential by Size, Application and State

Microturbine

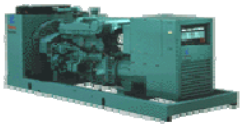
Turbine



Energy Prices

Technology Competition Analysis

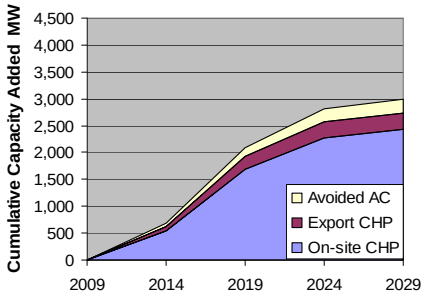
Recip. Engine



Fuel Cell

Output: Technology Competition by application, net power costs, emissions profiles

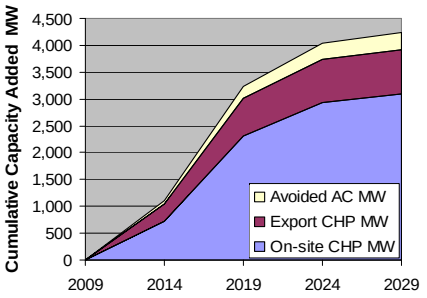
CHP Market Penetration



Base Case

Alternative Scenarios

Analysis of CHP Incentives

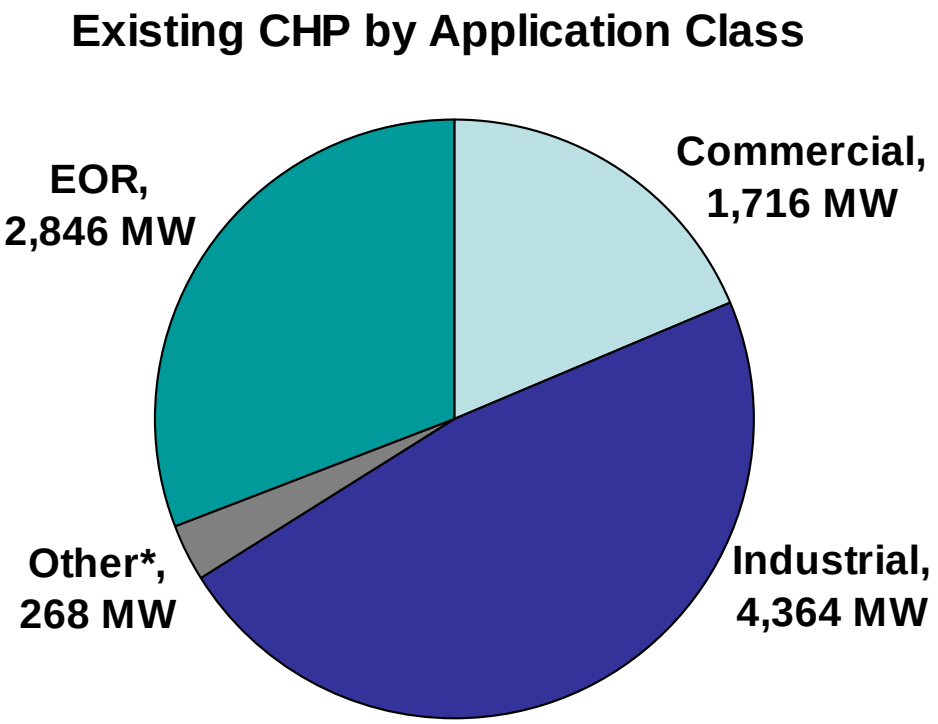


CHP Market Model

- Preliminary Analysis and Input Data
  - Existing CHP
  - Technical Market Potential by size and application from existing facilities and estimated growth over the forecast period (20 years)
  - Electric and gas prices today and over the forecast period
  - CHP technology cost and performance today and over the forecast period
- CHP Model Calculations
  - CHP payback analysis by technology, size, and application
  - Market acceptance as a function of payback
  - Market penetration over time
  - Summary of outputs

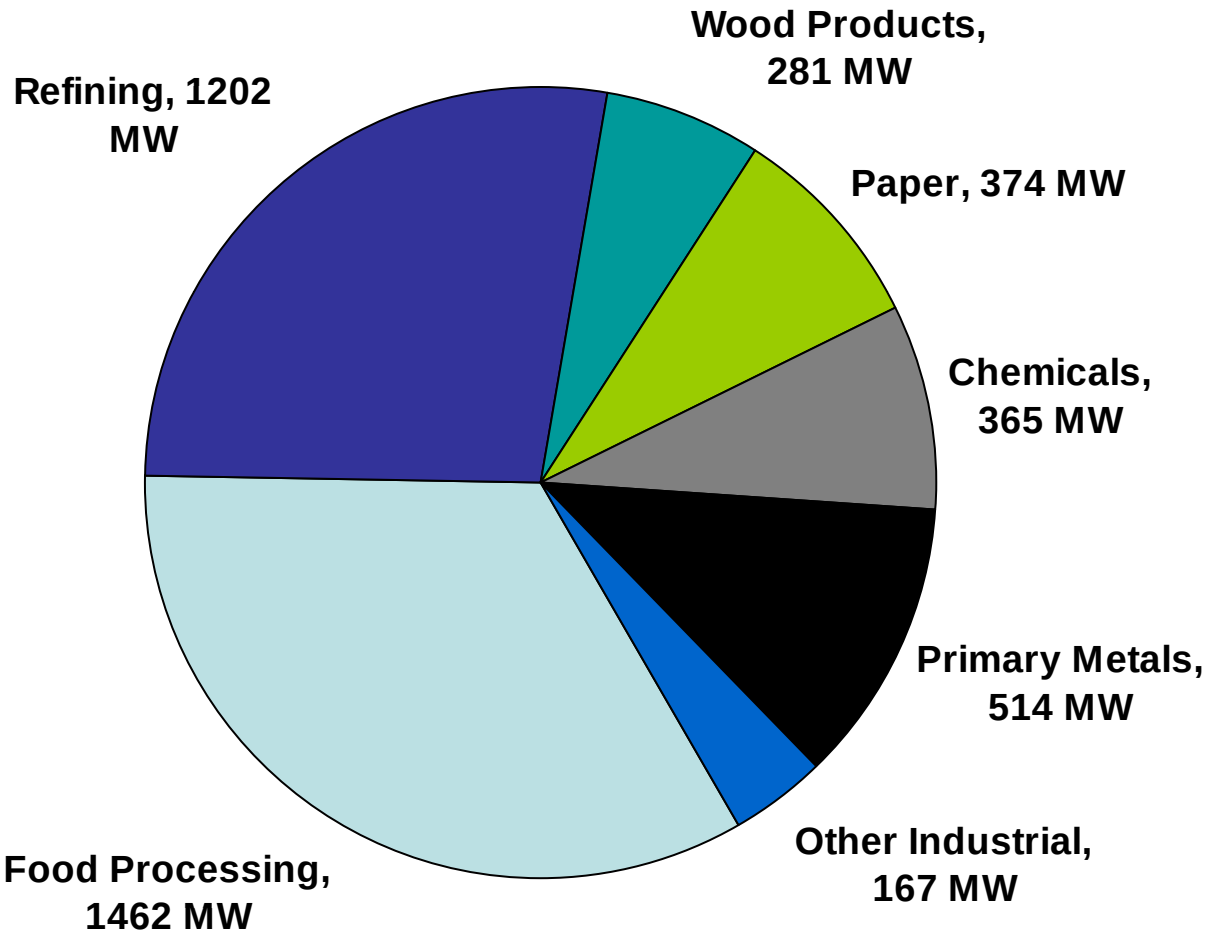
Existing CHP in California

- 1,186 Sites
- 9,194 MW

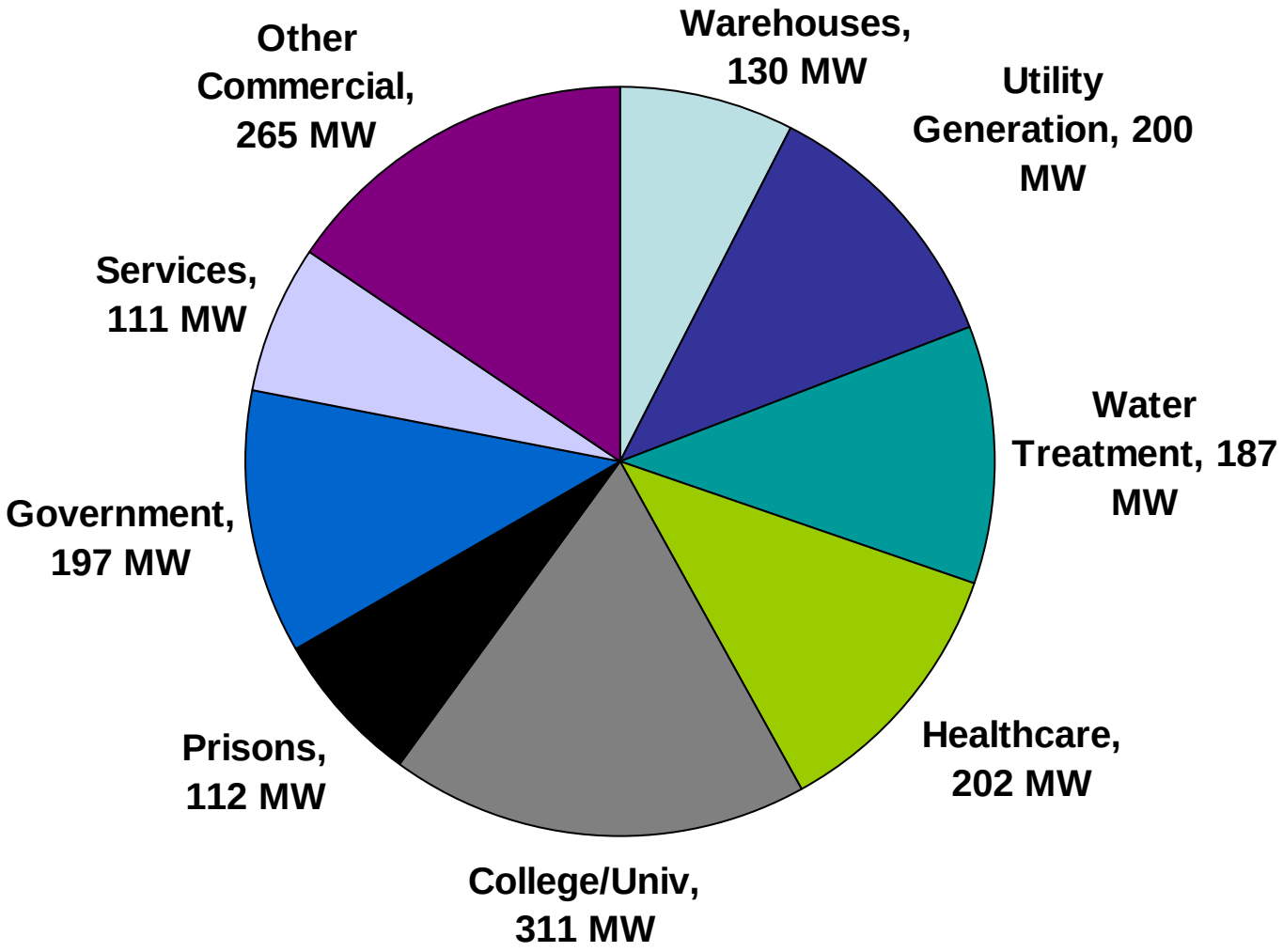


*Other = Agricultural and minerals,

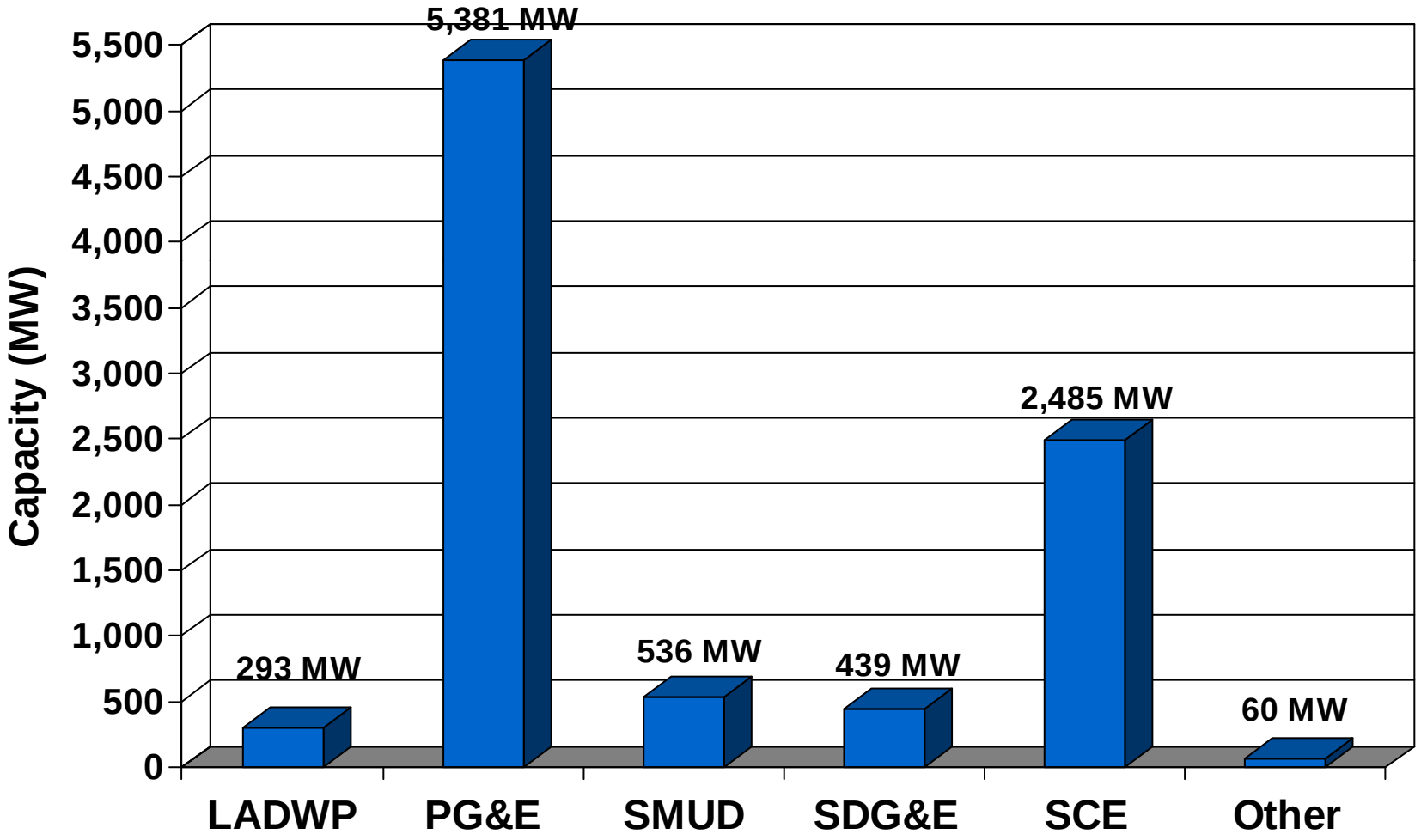
Existing Industrial CHP by Application



Existing Commercial CHP by Application



Existing CHP by Utility Region



QF Power – Significant Share of Power Generation in California

Investor Owned Utility	Fossil Fuel CHP MW	Biomass and Waste MW	CHP QF MW Electric
PG&E	2,457	613	3,070
SCE	2,046	182	2,228
SDG&E	331	6	337
Big 3 IOU Total	4,834	801	**5,635**

Source: Semi-annual utility QF Status Reports to CPUC 2008-1009

- Over 5,600 MW electric of fossil and biomass fueled CHP are under contract with the 3 IOUs
- QF power is 33% of PG&E generation cost, 28% of SCE generation cost

Analysis of CHP Target Markets – CHP Technical Potential

- Identification of target markets
- Evaluation of electric and thermal energy usage patterns
- CHP system configuration and size matching to site thermal energy usage
- Tabulation of CHP electrical generation capacity by application, market and size

Details of Approach and Results in Reference Section at the end

CHP Technical Potential Summary: Total Electrical Generating Potential

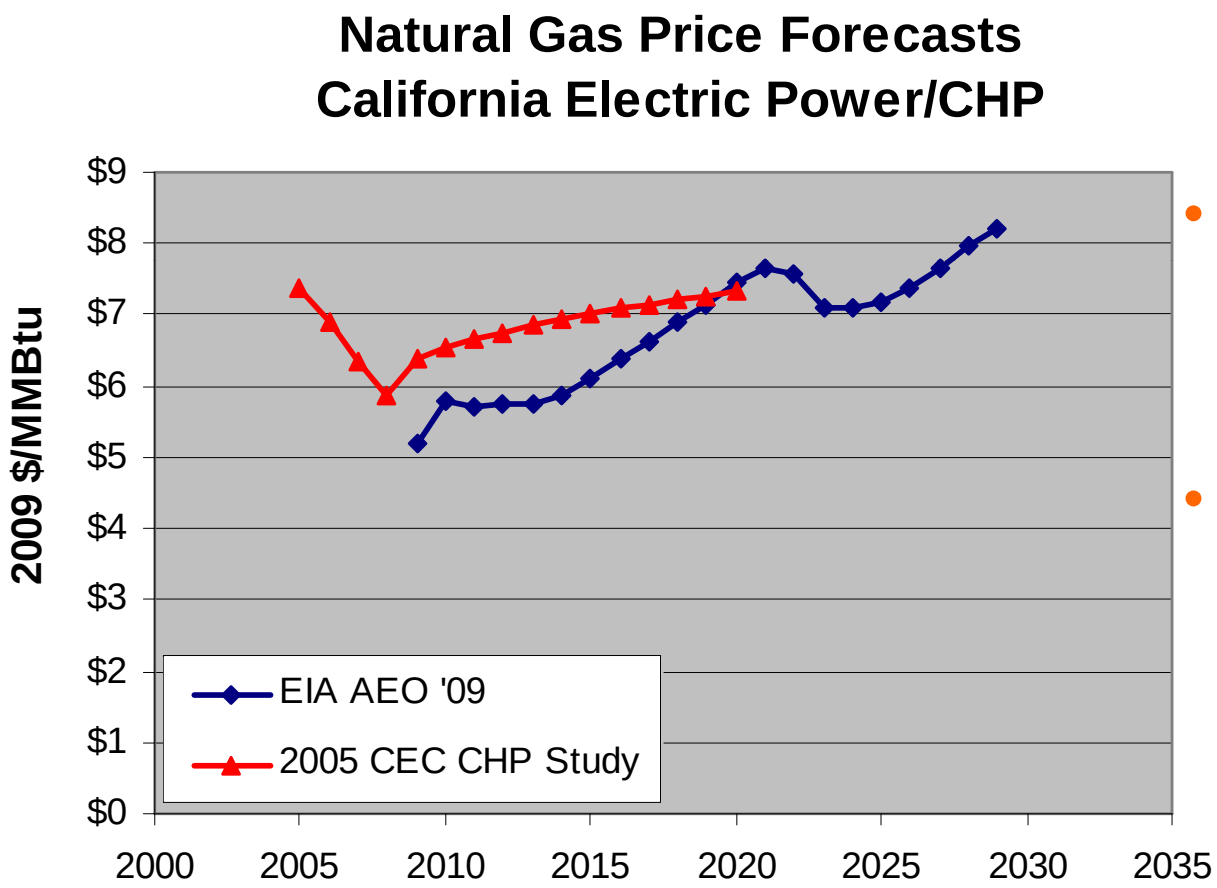
Market Segment	In Existing Facilities MW	In New Facilities MW	Total Technical Potential MW
Industrial On-site	4,157	438	4,595
Commercial On-site	7,371	1,611	8,981
Export < 20 MW (AB-1613)	1,014	122	1,135
Export > 20 MW	3,530	175	3,705
Total Technical Potential	16,071	2,346	18,417

- Existing facilities represent businesses that exist today that have unmet CHP potential – either through new or expanded CHP
- New facilities represent an estimate of economic growth in the target market segments over the next 20 years
- Electric capacity from generators shown – avoided air conditioning electricity and boiler fuel saved, not shown on this table

Base Case Energy Price Assumptions

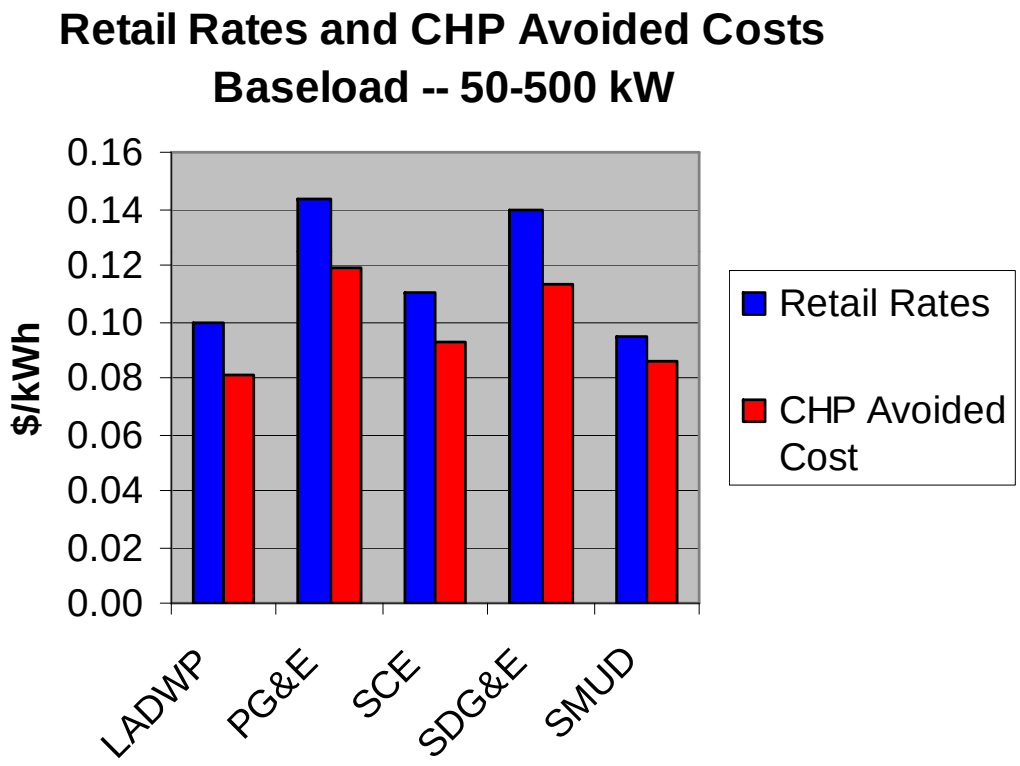
- EIA AEO 2009 Stimulus Case (April 2009) California –WECC gas prices to electric utilities used for EPG/CHP gas price
- Gas delivery markup differentials for CHP and boiler use
- Electric prices evaluated for current tariffs
  - Full Load slice – average unit electric cost savings for high load factor CHP
  - 4500 hour, peak weighted – average unit electric cost savings for intermediate load factor CHP
  - ~2000 hour, on peak – avoided retail power cost for CHP provided air conditioning
- Electric price escalation
  - T&D component assumed constant in real dollars
  - Generation component based on marginal cost of electricity from combined cycle power plant using EIA Cal-WECC EPG price track

Natural Gas Price Forecast



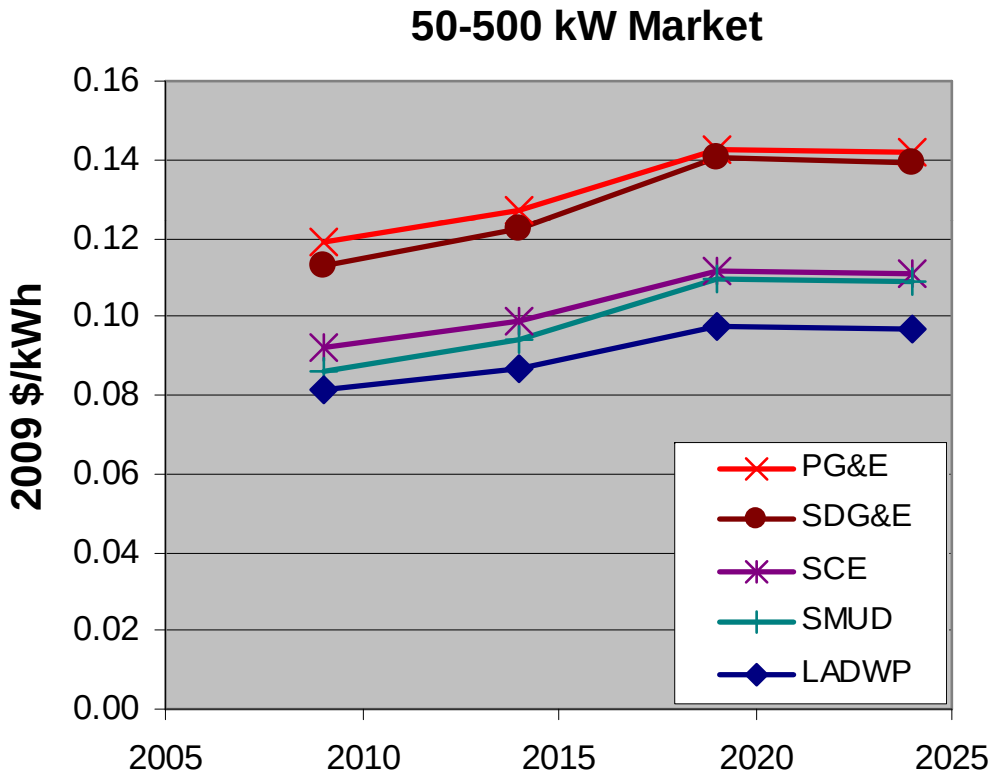
- EIA California EPG price is used for the base case 2009 CHP study
- Gas prices are lower than those used for the 2005 CHP market study
- Boiler fuel forecast assumed to be $1.20/MMBtu higher than EPG price (per analysis of PG&E tariff)

Retail Electric Price Analysis



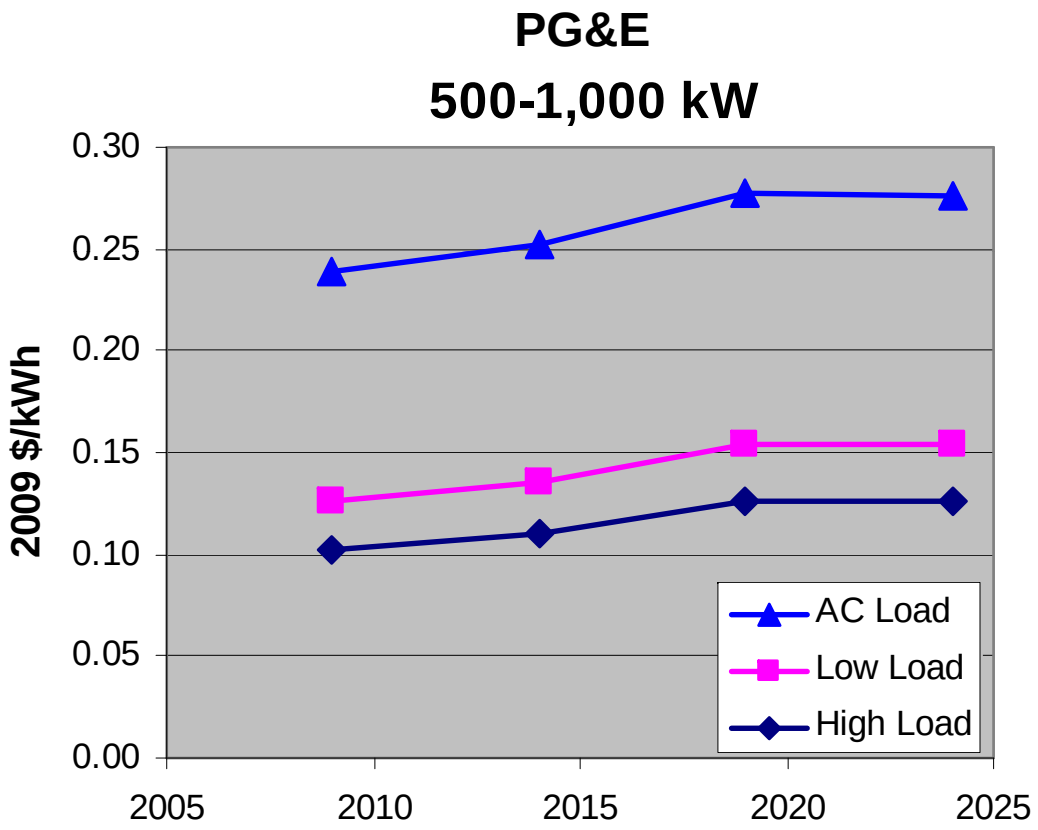
- Analyzed current tariffs for 5 major electric utilities
- Compared retail rates to without CHP to retail rates with CHP to derive avoided CHP costs or “average electricity cost savings”

Average Electricity Cost Savings
High Load Factor CHP – 50-500 kW



- Analysis of current tariffs with and without CHP
- Average savings based on CHP availability of 95% with 3 on-peak outages
- Escalation assumptions
  - T&D costs assumed fixed in real dollars
  - Generation portion based on the marginal cost of power from natural gas combined cycle power plant

Average Electricity Cost Savings
Effect of Load Factor on 500 kW to 5 MW Size



- AC savings based on retail rates for ~2000 hour on peak operation
- Low load based on peak weighted 4500 hours/year CHP operation
- High Load assumes constant CHP operation at 95% availability

Export Pricing (Feed-In-Tariff) Assumptions

- Prices are not established yet for CHP except for SMUD Feed-in Tariff (FIT)
- Other municipal FITs assumed to be the same as SMUD
- IOUs assumed to be 95% of 15-year market price referrent for renewable tariff
- Constant flat delivery of power to the utility during all time periods is assumed

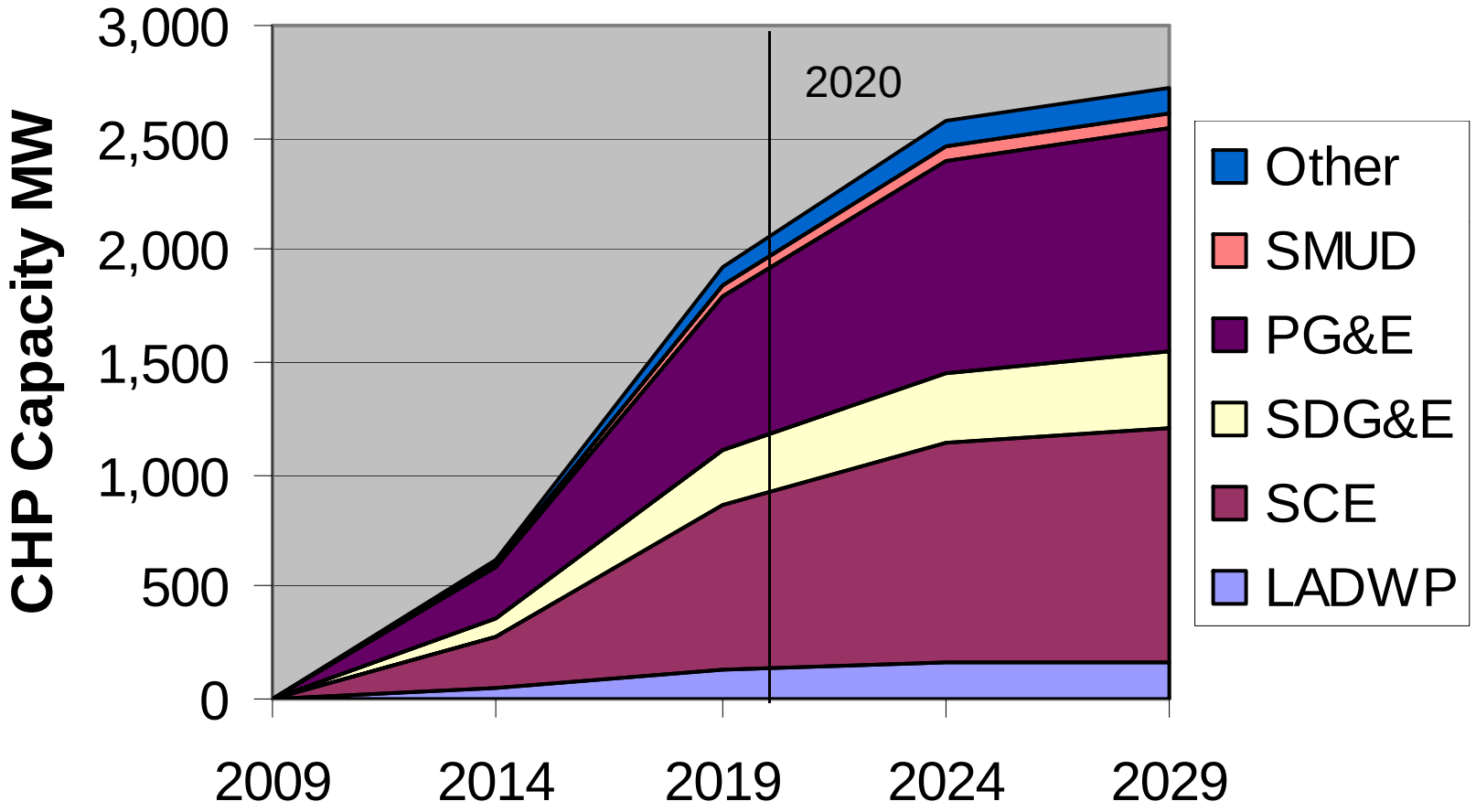
CHP Technology Cost and Performance

- Based on 2003 NREL report “Gas-Fired Distributed Energy Resource Technology Characterizations” with updated cost, performance and emissions data
  - Reciprocating engines: $2,475 - $1,250/kW
  - Microturbines: $3,000 - $2,900/kW
  - Fuel Cells: $7,000 - $5,800/kW
  - Gas Turbines: $1,900 - $1,080/kW
- All systems must meet NOx emissions of 0.07 lb/MWh
  - Recip engines meet with Three Way Catalyst (small) and SCR (medium to large) with thermal credit
- Improvements over time in cost and performance based on ongoing CEC, DOE and manufacturers programs

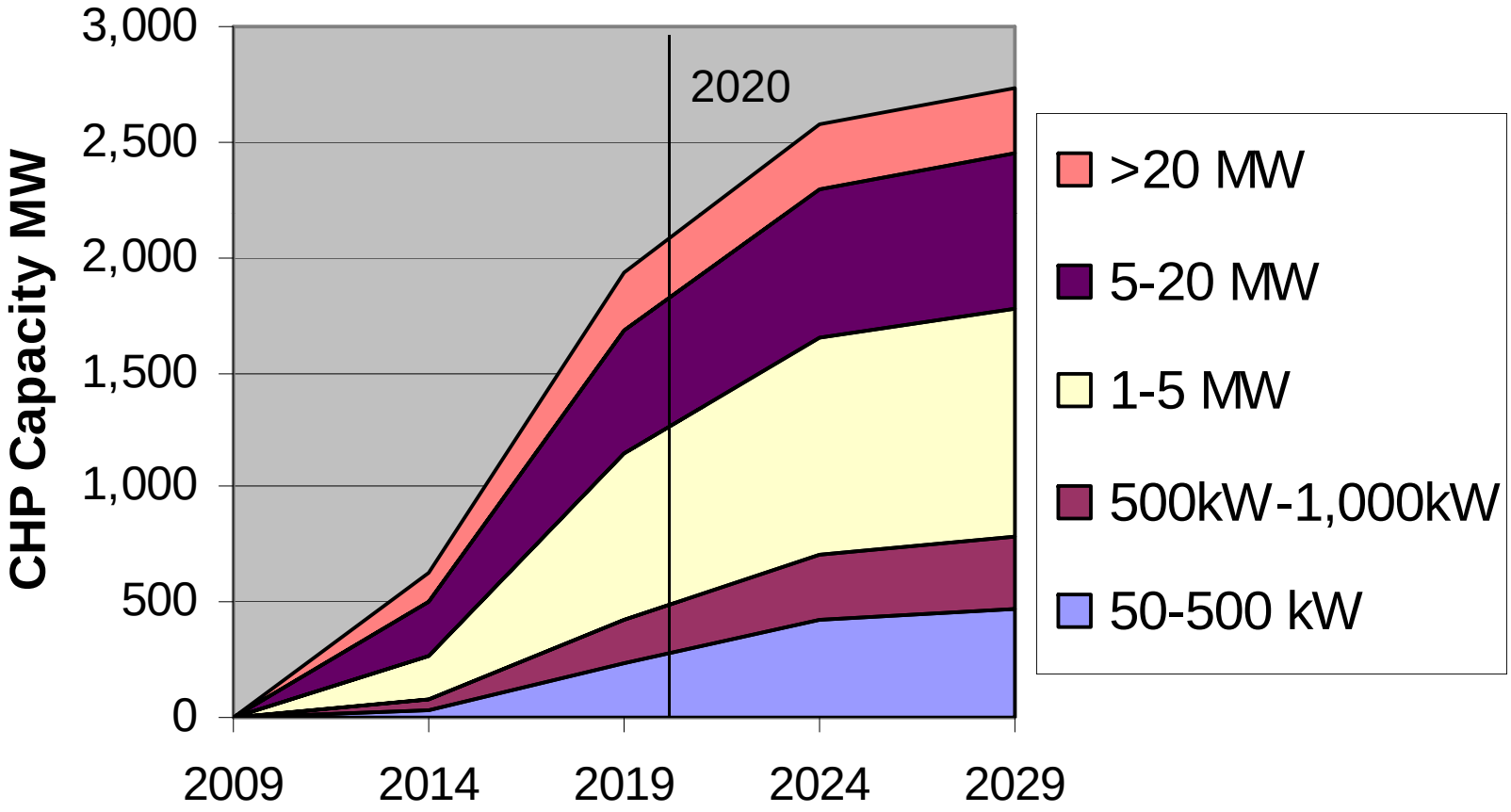
Scenario Definitions

- Base Case
  - Existing SGIP (fuel cells only)
  - Prices as shown
  - Export tariff for projects less than 20 MW
  - No export tariff or new contracts for CHP > 20 MW
- Restore SGIP
  - Base Case assumptions plus SGIP as previously implemented for 10 years
- Expanded Export
  - Tariff development for >20 MW systems based on marginal baseload electric price – natural gas combined cycle cost
- Avoided CO2 Payments for CHP
  - Payments for CHP based on savings compared to appropriate avoided generation mix (methodology discussed later)
  - Payments applied to on-site use, already included in FIT for renewable power and assumed in this study to apply to CHP power

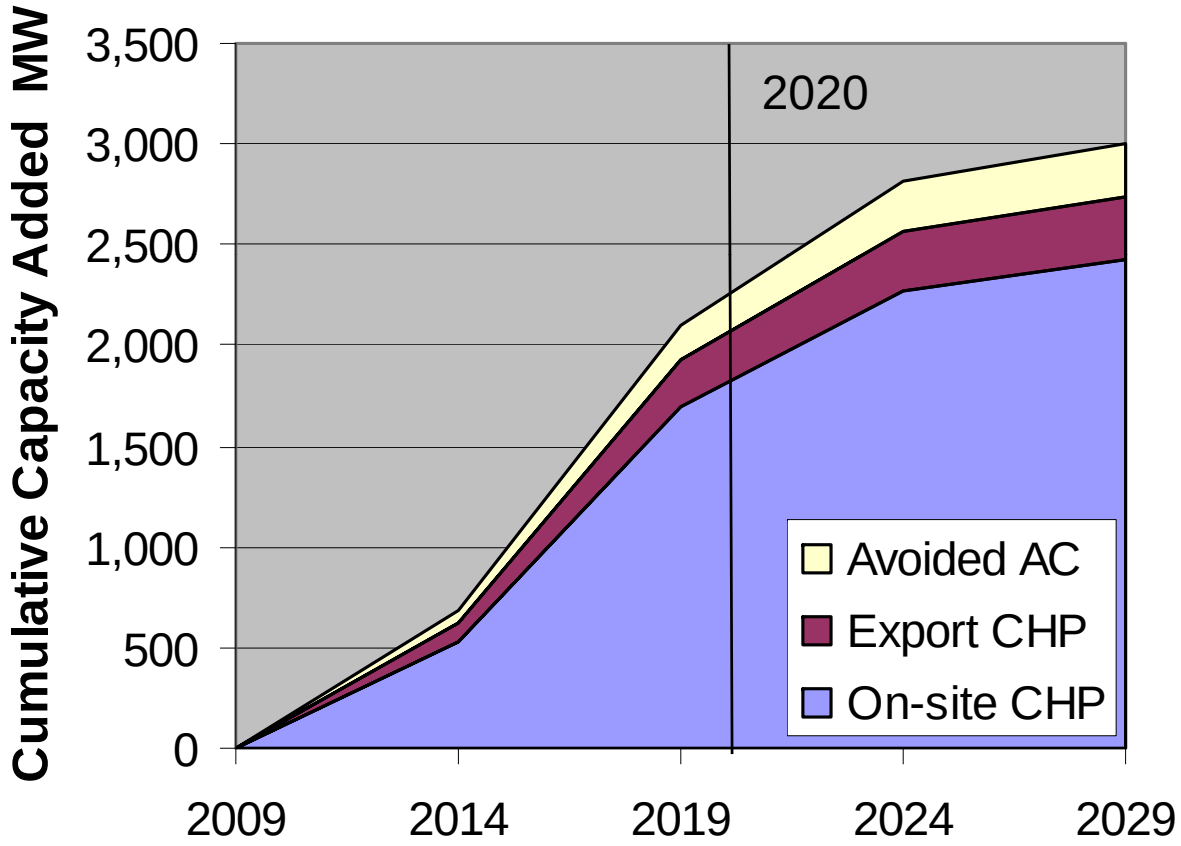
Base Case – Cumulative CHP Market Penetration by Utility



Base Case – Cumulative CHP Market Penetration by Size

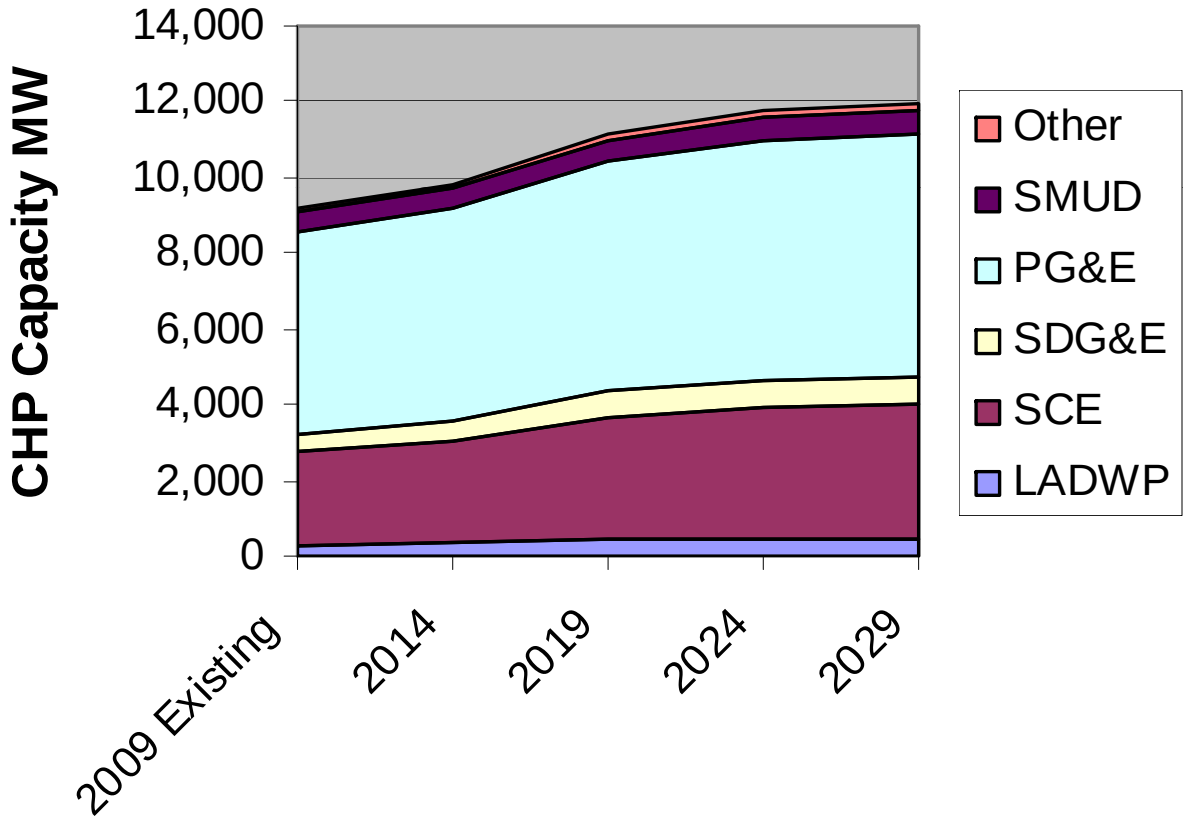


Base Case – Cumulative CHP Market Penetration by Type



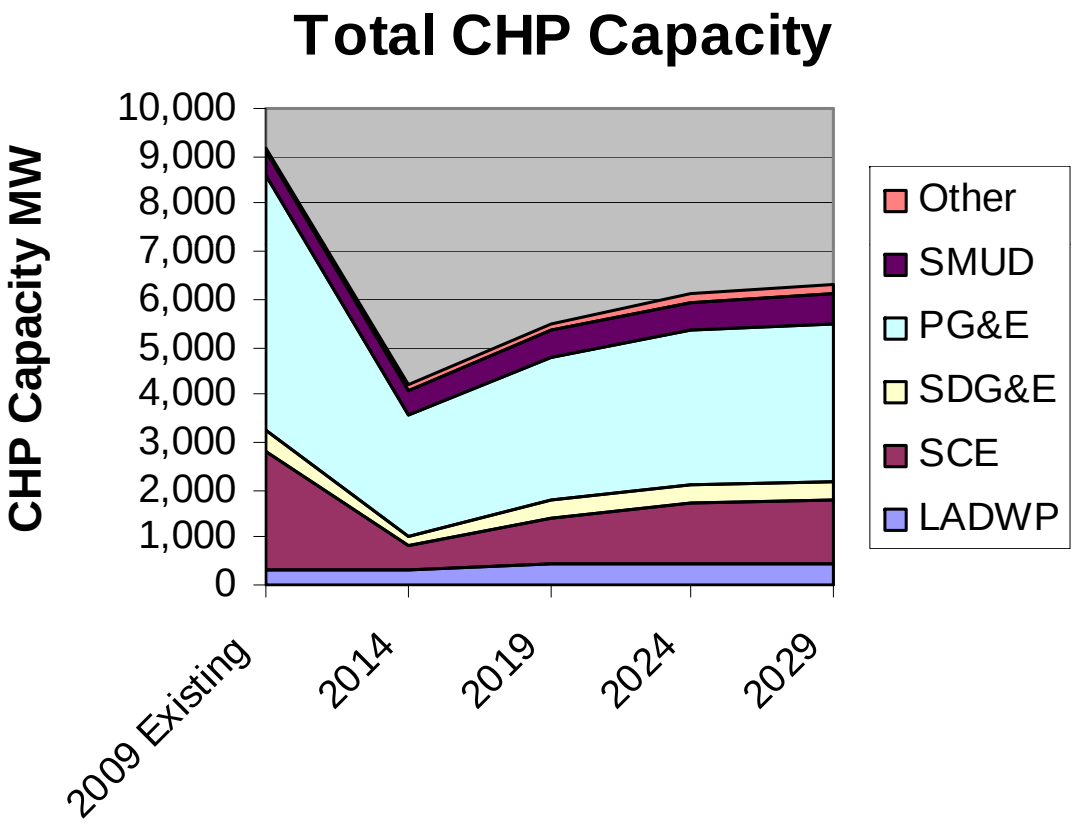
- Includes avoided electric AC capacity met by CHP thermal output (279 MW)
- AB-1613 capacity equals 304 MW

Base Case Market Penetration with Existing CHP Included



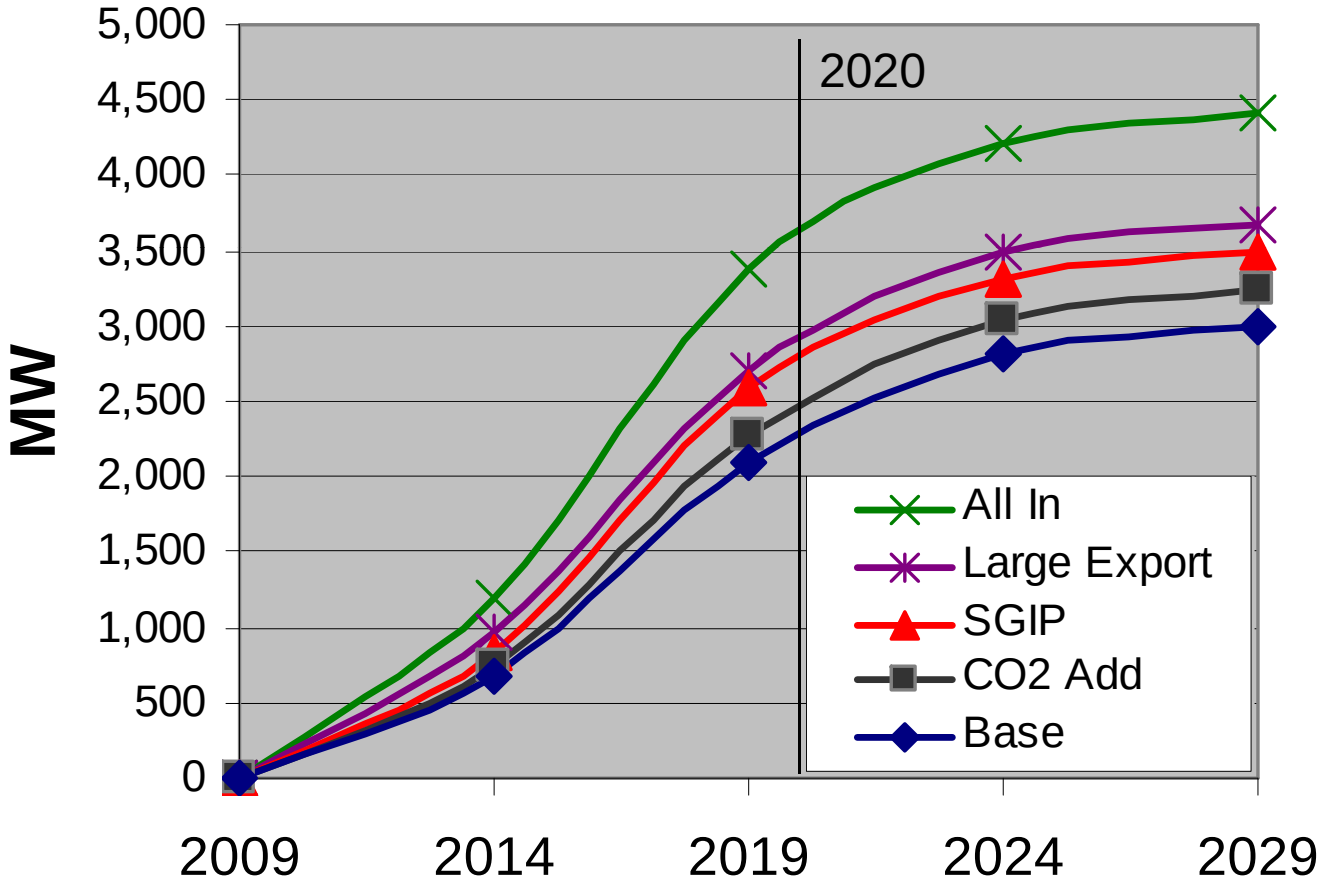
- 9,194 MW of existing CHP in California today
- Assume no reduction in existing CHP
- New CHP forecast shown on top of existing CHP

Base Case with Erosion of Existing CHP – Illustrative Case



- Base case forecast shown on top of modified existing CHP
- Large existing export CHP dropped out of existing QF market
- New CHP market penetration cannot offset loss of existing CHP

Cumulative CHP Market Penetration 2009-2029 by Scenario



Other Scenario Results

- Restore SGIP
  - Base Case assumptions plus SGIP as previously implemented for 10 years
  - 497 MW increase in cumulative market penetration in first 10 years
  - Impact is on small CHP up to 5 MW
- CO2 Payments
  - Payments for CHP based on savings compared to avoided CO2 emissions
  - $50/ton of avoided CO2 emissions payment assumed
  - 244 MW cumulative increase in CHP market penetration
- Large Export
  - Tariff development for >20 MW systems based on marginal baseload electric price – natural gas combined cycle cost
  - 671 MW cumulative increase in CHP market penetration
  - All increase is for systems larger than 20 MW based on
- All In Scenario
  - Includes all measures above
  - Nearly additive increase of 1,408 MW of cumulative market penetration compared to the individual increases by scenario

Export Market Sensitivity

Two sensitivity cases were run on CHP with power for the export market

AB-1613 – Reduced Tariff Assumption

- Feed In Tariff assumptions were lowered for the IOUs by 1.5 cents/kWh – based on renewable and CHP FIT relationships in SMUD existing tariff
- 2029 export market penetration reduced from 304 MW to 247 MW
- If CO2 payments were made to CHP facilities with this pricing the lost penetration would be restored

Large Export – Power Maximization

- Export technical potential was re-evaluated assuming combined cycle power generation with steam extraction (except for EOR which was unchanged)
- Technical potential increased from 3,530 MW to 6,037 MW (> 20 MW size)
- 2029 cumulative market penetration increased from 671 MW to 984 MW

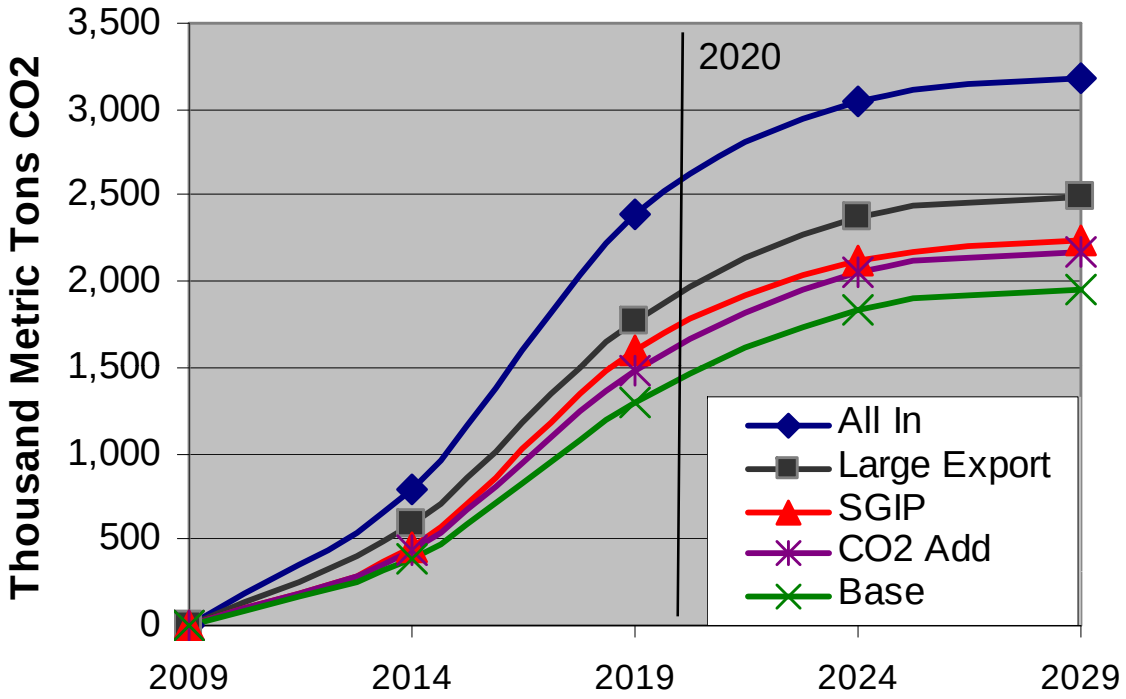
GHG Emissions Savings – Avoided Emissions

CHP System Load Factor	Avg Heat Rate at Generator Btu/kWh HHV	T&D Losses	Avg Heat Rate Delivered Btu/kWh HHV	Avoided CO2 Emissions lb/MWh
Baseload	7,460	5%	7,833	917
Intermediate Load	8,707	8%	9,403	1100
Avoided Electric Air Conditioning	10,487	13%	11,851	1387
Export Baseload	7,460	0%	7,460	873

Natural Gas Emissions Rate = 117 lb/MMBtu

- Avoided power emissions vary by the load factor representing a mixture of new and existing baseload and peaking power generation
- CHP for on-site use also avoids line losses through the T&D system
- Additional details in reference section

Annual CO2 Emissions Savings by Scenario



- 2 to 3.2 million metric tons of avoided CO2 emissions per year by 2029 depending on scenario
- Large export case has the highest CO2 reduction per added CHP MW
- CO2 Payment case has the second highest CO2 reduction per added CHP MW

Summary Results

- New market penetration in the base case (status quo) of just under 3,000 MW in 20 years
  - Includes 304 MW of AB-1613 export and 281 MW of avoided AC
- Policy Cases
  - Restore SGIP (SB-412) – add 497 MW
  - $50/ton avoided CO2 payments – add 244 MW
  - Large export at avoided system marginal generation costs – add 500 MW
  - Sum of all measures – add 1,241 MW
- GHG Impacts – 2-3.2 million metric tons annual avoided CO2 emissions by 2029 (20 years)
  - Large export scenario has highest per MW impact

Comparison to ARB Scoping Plan Goal

Scenario	Capacity MW	Output GWh/year	Avoided CO2 MMT/year	CO2 Savings Rate lb/MWh
ARB 2020 Goal	4,000	30,000	6.70	492
Base Case 2020	2,240	14,486	1.41	215
Base Case 2029	2,998	18,991	1.95	226
All In Case 2020	3,551	23,627	2.52	235
All In Case 2029	4,406	28,806	3.18	243

- Scoping Goal is optimistic both in terms of level of penetration and in expected GHG emissions savings
- Under current policies, CHP will fall well short of these goals
- With aggressive CHP stimulation (all in case) the market penetration goals can be met a a few years beyond 2020
- CO2 savings in the All In case market results are about half of the Scoping Plan Goal

Large versus Small CHP: Market Penetration and Issues

CHP Markets and Measures	Large CHP MW	Small CHP MW
Existing QF Contracts	6,000	
Other Existing CHP	1,900	1,200
Total Existing	7,900	1,200
New On-site Market Penetration Status Quo	278	2,416
Added New from AB 1613 Export		304
Added New from Restoring SGIP		497
Added New from CO2 Payments for on-site CHP	23	208
Large Export -- business focus	671	
Large Export -- Maximize power outputs (add)	223	
Total New	1,195	3,425

- Existing market is 87% “big stuff”, new growth will be 75% “small stuff”
- Large CHP and small CHP face different market issues and react to different market stimuli
  - Small CHP stimulus – Economic feed in tariff, SGIP incentives, RD&D
  - Large CHP stimulus – Preservation of existing contracts, Facilitation of large system contracting for new projects

Observations and Conclusions

- Greatest market and GHG benefit comes from preserving existing large CHP and pursuing remaining large CHP technical potential
- Small CHP is the largest emerging market in the Base Case with 90% of the market penetration in sizes below 20 MW
- Small CHP has additional benefits for California that were not modeled
  - Reduction in the need for T&D investments
  - Increased system and customer reliability
  - Technical innovation and development of economic business opportunities

Recommendations

- Meeting ARB CHP Goals
  - Market forces appear to be inadequate – aggressive polices are needed to reduce barriers and increase economic value to the customer
  - Technical potential exists in both large industrial and smaller industrial and commercial markets to meet the goals, and reasonable economic value can be achieved, but perceived risks need to be addressed to stimulate market response
  - Maximum thermal utilization needs to be encouraged in the commercial markets and more efficient thermally activated cooling systems need to be developed and demonstrated
- Removing Barriers
  - Address lack of information or awareness
    - Demonstration of innovative technologies and applications
    - Education, information, training resources
  - Reduce project risk
    - Establish long term contracting approaches
    - Innovative natural gas contracting to remove effects of volatility
  - Improve project economics especially for small CHP
    - Reduce the degree of nonbypassable charges that CHP must pay and encourage economic treatment for CHP
    - Reduce equipment costs and increase performance
    - Verify small CHP cost and performance through development and demonstration
  - Provide direct value for CO2 emissions reduction – CO2 payments for CHP
  - Provide incentives to internalize other CHP benefits – T&D support, peak capacity, system reliability

CHP Market Presentation -- Glossary

AB-1613 -- Waste Heat and Carbon Emissions Reduction Act

AB-1969 -- Renewable electric generation facilities: feed-in tariffs (actually AB-1807)

AB-32 -- California Global Warming Solutions Act 2006

AC -- Air conditioning

AEO -- Annual Energy Outlook, long range forecast publication of EIA

ARB -- California Air Resources Board

CBECS -- Commercial Buildings Energy Consumption Survey, publication of EIA

CEPD -- Commercial Energy Plant Database

CEUS -- California Energy Utilization Survey

CHP -- Combined heat and power

CO2 -- Carbon dioxide

CPUC -- California Public Utilities Commission

D&B -- Dun & Bradstreet

DER -- Distributed energy resources

DOE -- U.S. Department of Energy

EIA -- U.S. Energy Information Administration

EOR -- Enhanced oil recovery

EPG -- Electric Power Generation

FIT -- Feed-in tariff

GHG -- Greenhouse gas

GT -- Gas turbine

GT-CC -- Gas turbine combined cycle

HHV -- Higher heating value

IOU -- Investor owned utility

LADWP -- Los Angeles Division of Water and Power

LBNL -- Lawrence Berkeley National Laboratory

LHV -- Lower heating value

MECS -- Manufacturers Energy Consumption Survey, publication of EIA

MIPD -- Major Industrial Plant Database

NOx -- Nitrogen oxides

NREL -- National Renewable Energy Laboratory

PG&E -- Pacific Gas and Electric Company

PURPA -- Public Utility Regulatory Policies Act of 1978

QF -- Qualifying Facility, legal designation of CHP under PURPA

SB-412 -- Requires CPUC to continue SGIP

SCE -- Southern California Edison Company

SCR -- Selective catalytic reduction

SDG&E -- San Diego Gas and Electric Company

SGIP -- Self Generation Incentive Program

SMUD -- Sacramento Municipa Utility District

T&D -- Transmission and distribution

WECC -- Western Electric Coordinating Council